# *Chapter 2.*
# *Contents of the Project*

# Chapter 2. Contents of the Project

## 2-1 Basic Concept of the Project

The purpose of this report is to summarize the field work undertaken by the JICA Study Team for the improvement of water intake facilities at the Upper Water Source Area and transmission pump station, and to review the existing water supply facilities to resolve issues such as the lack of water supply volume predicted in the future. The lack of water supply is due to rapid population growth.

The City of Ulaanbaatar has an urban development master plan, "Master Plan 2020 for Ulaanbaatar City", which was approved by the cabinet in May 2002. The studies and the construction projects outlined in the Master Plan have been initiated. In accordance with the Master Plan, priority projects include the construction of apartment buildings, power facilities, factories and water supply facilities. The Ministry of Trade and Industry Mineral Resources Office has started a study on water source utilization to meet the increasing water demand due to rapid population growth.

In this project, construction of 16 wells with good water quality and a design capacity of 18,000 cu.m/day, and rehabilitation of the existing transmission pumps in the station and related facilities are required to provide potable drinking water from the Upper Water Source Area to the City. Implementation of this project will result in supply of sufficient water to meet demand until 2010.

This project will also contribute to establishment of an efficient organization for operation, control and management of the system, as well as providing training to the staff to improve their competence. Further, the project will assist the self-supporting management of USAG by upgrading of profitability through development of water supply facilities and operational efficiency.

Table 2-1 Summary of Projects

| | |
|---|---|
| 1. Rehabilitation | (1)Transmission Pump Station at Upper Water Source: 5 sets |
| | (2)Distribution Pump Station at Central Water Source: 2 sets |
| 2. New Facilities | (1)Well pump Station at Upper Water Source: 16 sets (Include Raw Water Transmission Pipe) |
| | (2)Water Hammer Prevention Equipment |
| 3. Supply Material | (1) Insulation Works ( at well pump periphery pipe) |
| 4. Soft Component | Support for Reinforcement of Administration, Management of Facilities, Leakage Prevention, Water Quality Monitoring and a Campaign for enlightenment and diffusion |

## 2-2 Basic Design of the Requested Japanese Assistance

### 2-2-1 Design Policy

#### (1) Basic Policy

In this project, the target year to meet water demand is 2010. The plan will be developed to satisfy the corresponding water demand.

### (2) Policy of Natural Condition

Ulaanbaatar City is approximately 1500 m above sea level. The climate is continental with the average annual temperature of Zero degrees Celsius. According to the Ulaanbaatar weather station, the average temperature observed in the past five years indicated a maximum temperature of 34.6 degrees Celsius and minimum temperature of – 35.4 degrees Celsius.

During a period of seven months (April to October), the average daily temperature does not drop to below Zero degrees Celsius. This is the period that construction work will be done. During winter (October to April), because of the extremely low temperature, thermal insulation for facilities such as plumbing, machinery and electrical equipment is required.

The freezing depth is more than 3 m below the ground surface. All piping construction outside of buildings needs to be laid below the freezing depth. The average annual precipitation is only 257 mm. Most of the rain falls between May and September. Flooding caused by rainfall occurs occasionally. Consequently, the ground level for new wells will be designed with consideration of these conditions.

### (3) Policy of Social Economy Condition

For Public Agencies of the Mongolian government, the weekly holiday is on Saturday and Sunday. There are 10 national holidays, including the two longest national holidays, the Lunar New Year and the Naadam. A work week of 40 hours is prescribed in labor rule. The labor rule is considered in the execution plan.

### (4) Policy of Law, Institution and Standard

As for the future construction site for new wells at the upstream water source, USAG has the right to use the land since USAG owns an existing well field. A law regarding the land ownership was implemented in May 2003 but the policy of the order of priority is being traditionally respected.

### (5) Policy of Utilization of the Local Construction Company and Material

A local construction company, which has significant experience in execution of construction projects funded by International organizations, will be utilized as a subcontractor. USAG also has a list of prospective subcontractors for the well drilling construction.

Construction materials are abundant in the local market but mechanical and electrical equipment is imported from the foreign countries. USAG procures most imported equipment from Russia. Recently, imported products from China are becoming more popular. However, the poor quality of Chinese products results in reliability and durability problems. USAG is considering purchasing products from a Japanese-European merged enterprise that meets international standard requirements.

### (6) Policy of Operation/Maintenance Administrative Ability for Enforcement Organization

USAG has been properly maintaining and managing several facilities and products that were manufactured in the former Soviet Union. Most of the facilities are utilized properly. Most of the system that is functional was funded by World Bank and other International organizations.

### (7) Policy of Grade Setting of the Equipment, Machinery and Materials

Criteria for equipment selection include energy efficiency, durability, and reliability. The equipment selected should be able to reduce operating expenses.

### (8) Policy of Construction Method and the Construction Period

The required construction period is likely to be two years, during the summer months only. Two years will be required for construction of 13 km of raw water transmission pipeline and development of the new well field with 16-wells.

It is possible to design and manufacture equipment in winter. Therefore, bidding and contracting may be started from autumn.

## 2-2-2 Basic Plan

### 2-2-2-1 Basic Data

### (1) Service Area

The service area for this project is the same area supplied by USAG at the present time. Specifically, some places that are located far from the existing service area, such as Bagakhangai and Baganuur, are excluded from the service area.

### (2) Water Demand Projection

#### 1) Past Population Increase

The population increase over the past ten years is shown in Table 2-2. The nationwide total rate of population growth between the years 1992 and 2002 is estimated at 1.5% due to population movement to urban areas.

Table 2-2 Population Increase in Past

| Year | Ulaanbaatar City Population (Thousands) | Increasing Rate |
|---|---|---|
| 1992 | 589.0 | — |
| 1993 | 598.6 | 1.6 |
| 1994 | 609.9 | 1.9 |
| 1995 | 619.2 | 1.5 |
| 1996 | 633.9 | 2.4 |
| 1997 | 649.8 | 2.5 |
| 1998 | 672.9 | 3.6 |
| 1999 | 768.2 | 14.2 |
| 2000 | 789.2 | 2.7 |
| 2001 | 812.5 | 3.0 |
| 2002 | 846.5 | 4.2 |

Source: Statistics from Ulaanbaatar City

### 2) Future Population Projections

#### a. Projected Future Population in USAG Service Area

The planning horizon for projected future population is 2020, in the Master Plan 2020 for Ulaanbaatar City. In the Master Plan, the projected population was calculated using two different assumptions, based on the population in year 2000 and averaging the two values.

Case-1: calculated in the consideration of the delivery, death rate and also social increase in the past.

Case-2: calculated same as Case-1 but restricting social increase.

Table 2-3 Future Population (Case-a)

| | 2000 | 2005 | 2010 |
|---|---|---|---|
| Case-1 (Thousand) | 718.7 | 836.7 | 985.8 |
| Case-2 (Thousand) | | 826.0 | 947.2 |
| Average (Thousand) | -- | 831.4 | 966.5 |

Notes: Review of population in Master Plan 2020
Adopted value is the mean value of Case-1 and Case-2
A part of Nalaih, Bagakhangai and Baganuur are not included

In this study, the average population projection above will be adopted. On the other hand, USAG projections include the dwellers in Nalaih in addition to the areas covered in Table 2-3. The population of Nalaih has remained approximately the same for the past four years, i.e. population of 23,600 in year 1999, 23,400 in year 2000, 23,400 in year 2001 and 24,000 in year 2002. The future population in planned service area is 990,500 for the target year in 2010, including 24,000 people in Nalaih.

Table 2-4 Future Population (Case-b)

| Year | 2005 | 2010 |
|---|---|---|
| Future Population (USAG Service Area) | 855,400 | 990,500 |

#### b. Dweller Number of Apartment and Ger

The proportion of people living in apartments and Ger area in the past three years is almost the same. The projected population living in apartments and Ger area in each year is shown in Table 2-5. An estimate that 51% of the population will be living in apartments in the future will be used in this project.

Table 2-5 Dweller Number of Apartment and Ger

| Year | Population Living in Apartments | | Population Living in Ger | |
|---|---|---|---|---|
| | Total (thousands) | Percentage | Total (thousands) | Percentage |
| 2005 | 436.3 | 51.0 | 419.1 | 49.0 |
| 2010 | 505.2 | 51.0 | 485.3 | 49.0 |

### 3) Projection of Water Demand

#### a. Domestic Water

**Development of Projection of Per Capita Water Demand**

The recent water demand of per capita in apartments and Ger area is shown in Table 2-6.

Table 2-6 Per Capita Water Demand

| Year | Apartment (L/capita/day) | Ger (L/capita/day) |
|---|---|---|
| 1997 | 420 | 4.6 |
| 1998 | 450 | 4.8 |
| 1999 | 431 | 4.9 |
| 2000 | 358 | 4.7 |
| 2001 | 318 | 5.3 |
| 2002 | 287 | 5.7 |

The water demand for the apartment dweller is calculated by subtracting the total amount of water supplied to the enterprises, such as public institutions (including government agencies, public offices, hospitals, schools) and factories, from the total amount of water supplied by USAG to CTP. This amount of water includes the total water consumption and the water leakage from CTP to taps.

Recently, per capita water demand is decreasing rapidly due to the repair of leaking taps in houses and the prevention of leakage of water in the distribution system, and by adopting a commodity charge system instead of a fixed rate system. OSNAAG conducts a two-month water conservation campaign every year during which time the OSNAAG offers an inexpensive price for the repair of the broken water devices.

In this project, the projected water demand for people living in apartments in 2010 is 250 liters per capita per day. On the other hand, the water demand in Ger area is increasing somewhat. Currently, water is mainly supplied to storage tanks by trucks water tank vehicles. However the water distribution system is being upgraded and previously unsatisfied demand is being met.

The projected water demand in 2010 is estimated to be 25 liter per capita per day, which is the value that was adopted in the Master Plan.

**Future Domestic Water Demand**

The projected domestic water demand is 138,433 cu.m/day in 2010. This value was determined by multiplying the projected per capita water demand values by the total number of apartment dwellers and gel dwellers.

Table 2-7 Future Water demand (cu.m /day)

| year | 2002 | 2010 |
|---|---|---|
| Apartment | 98,088 | 126,300 |
| Ger | 1,850 | 12,133 |

**b. Non-Domestic Water Demand**

The water demand of private enterprises, public institutions and factories is calculated below. The amount of drinking water to be supplied to private enterprises and public institutions is expected to increase by 3% per year from 2002 through 2010. This rate of increase corresponds to the rate that the population is increasing. The water demand of industrial factories is expected to increase by 10,000 cu.m /day between 2002 and 2010.

Table 2-8 Prediction of Non-Domestic Water Demand (cu.m /day)

| Year | 2002 | 2005 | 2010 |
|---|---|---|---|
| Private enterprises | 15,793 | 17,257 | 20,006 |
| Public Institutions | 2,390 | 13,539 | 15,695 |
| Industrial Factories | 9,287 | 13,270 | 19,287 |

Note: without metering facilities, used conversion factor to assume water demand at 2002.

**c. Unaccounted Water**

The non-revenue earning water includes water system losses resulting from leakage, un-metered, and water for maintenance of water pipelines between pump stations owned by USAG and the CTP station owned by OSNAAG. In 2002 the amount of leakage water was 10.5 % or 16,147cu.m/day. However, this figure excludes water leakage between the CTP station and taps.

The estimated future unaccounted water is 16,100 cu.m/day. USAG has been conducting repair work recently to minimize water leaks. Also, leakage from recently installed pipelines is minimal. Therefore, it is possible that USAG has the capability to control the leakage issue. The estimated future unaccounted water is 16,100 cu.m/day.

**d. Rate of Loading**

To determine the existing rate of loading, the average rate of loading from the year 1999 to 2002 was calculated. The daily average water consumption is divided by the daily maximum water consumption and multiplied by 100. During 1999 to 2002, the rate of loading is 86.9%, 83.4%, 88.6% and 86.3%, respectively for each year yielding an average of 86.3%.

The water demand in the Ulaanbaatar City is mainly for drinking water. This demand is relatively constant. In this project, 86.3% will be used as an estimate of the future rate of loading, based on average of four years.

**e. Future Water Demand**

Following Table 2-9 shows the average daily water demand and maximum daily water demand.

Table 2-9 Estimated Water Demand (cu.m /day)

| Year | 2002 | 2010 |
|---|---|---|
| Apartment | 98,088 | 126,300 |
| Ger | 1,850 | 12,133 |
| Private Companies | 15,793 | 20,006 |
| Public Institutions | 12,390 | 15,695 |
| Industrial Factories | 9,287 | 19,287 |
| Sub-total | 137,408 | 193,421 |
| Unaccounted Water | 16,147 | 16,100 |
| Average daily Water Demand | 153,555 | 209,500 |
| Maximum daily Water Demand | 184,227 | 240,000 |

### (3) Plan for Facility Capacity

There are existing water sources located at the meat complex, industrial, as well as central area with a total possible total yield of 222,000 cu.m /day. According to the study, additional 18,000 cu.m/day water is required in 2010. In this project, Upper Water Source Area development yielding 18,000 cu.m/day of water is required, combined with utilization of the existing transmission main system. Also, it is required to install new water facilities such as wells, a raw water transmission pipeline, as well as rehabilitation of transmission pumps and other related facilities.

In the Upper Water Source Area, USAG has obtained the permission for a 90,000 cu.m/day maximum water intake. The water intake was approved by the Resources Savings Administration Bureau of Mongolia. The intake amount is broken down into 72,000 cu.m/day as current yield amount and 18,000 cu.m/day as future yield amount.

## 2-2-2-2 Plan on Intake Facility in Upper Water Source (Well Pumps)

### (1) Wells

#### 1) Basic Policy

The site for construction of the wells at the down stream water source between existing transmission pipeline and Tuul River in the Upper Water Source Area was selected for the following reasons:

- USAG already has the water rights at Upper Water Source Area.
- There is the possibility of water contamination in Nalaih area by drainage of sewage from the swamp and creeks on the south side.
- The cost for construction of raw water transmission pipeline, maintenance and operation is expected to be less because of the shorter distance to the existing transmission pump station.
- The existing raw water transmission main in the opposite Tuul River area has the potential for contamination because it is being used as the summer campground and field for nomads.

#### 2) Result of Electro-Magnetic Survey

The study team carried out an analysis of the ground water level, groundwater basin as well as geological structure such as the depth, thickness, extent of bedrock and gravel layer by use of electrical resistance surveying equipment at various locations. The site that was investigated is on the south side of existing wells along the Tuul River. Figure 2-1 shows the site location and Table 2-10 shows the result of analysis.

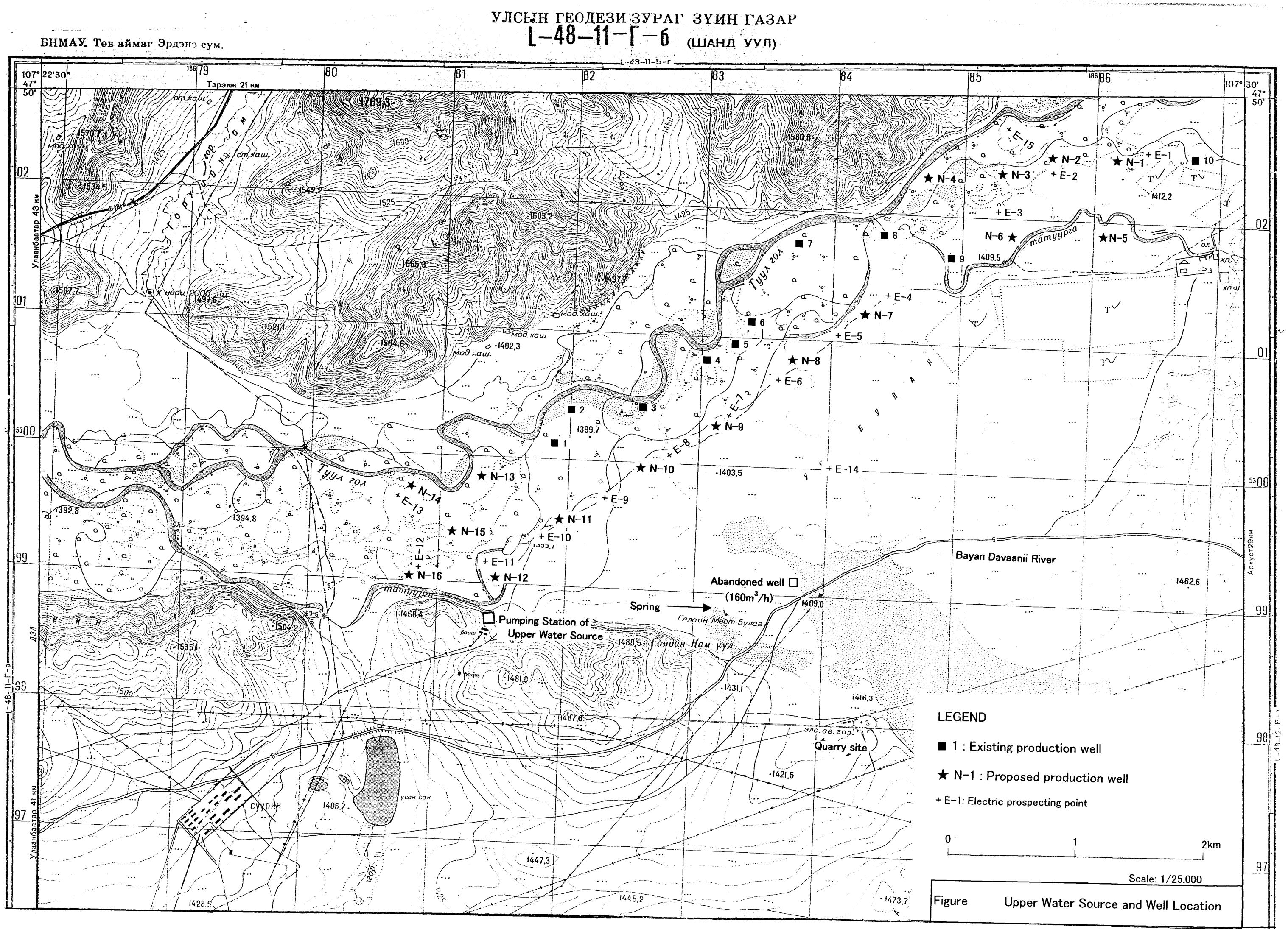



Figure 2-1 Location Map of Electrical Resistivity Testing and Proposed Wells

The results of the electric resistivity survey are as follows.

Table 2-10 Result of Electric Resistivity Survey

| Number of survey point | No. in Figure 2-2-1 | Thickness of 1st layer (m) | Aquifer thickness (m) | | | Depth to bedrock (m) | Remarks |
|---|---|---|---|---|---|---|---|
| | | | 2nd layer (m) | 3rd layer (m) | Total (m) | | |
| VES-1 | E-1 | 9.6 | 9.6 | 15.2 | 24.8 | 34.3 | Along the small creek. Top soil will be 1m thickness, GWL*: -1.5 to -2m |
| VES-2 | E-2 | 5.5 | 13.0 | 18.3 | 31.3 | 36.8 | |
| VES-3 | E-3 | 3.9 | 9.2 | 20.8 | 30.0 | 33.9 | |
| VES-4 | E-4 | 6.6 | 16.9 | 21.6 | 38.5 | 45.1 | |
| VES-5 | E-5 | 4.4 | 14.9 | 25.1 | 40.0 | 44.4 | |
| VES-6 | E-6 | 1.7 | 10.2 | - | unknown | unknown | It may be located in the fault zone. |
| VES-7 | E-7 | 8.4 | 15.6 | 25.5 | 41.1 | 49.6 | |
| VES-8 | E-8 | 3.6 | 9.0 | 14.7 | 23.7 | 27.4 | |
| VES-9 | E-9 | 2.8 | 8.3 | 18.8 | 27.1 | 29.9 | |
| VES-10 | E-10 | 2.8 | 8.2 | 20.4 | 28.6 | 31.4 | |
| VES-11 | E-11 | 4.7 | 15.4 | 14.8 | 30.2 | 34.9 | |
| VES-12 | E-12 | 11.3 | 13.5 | - | 13.5 | 24.8 | Top soil will be less than 1m thickness, GWL:±2m |
| VES-13 | E-13 | 2.2 | 5.3 | 17.2 | 22.5 | 24.6 | |
| VES-14 | E-14 | 1.8 | 14.7 | - | unknown | unknown | It is located in the alluvial fan of Bayan Davaanii river. Depth to bedrock is estimated more than 50 m. |
| VES-15 | E-15 | 3.9 | 10.4 | 12.8 | 23.2 | 27.1 | |

*: GWL; Ground Water Table below the ground surface

The property of each layer is described below:

First layer: Clayey soil (composed of silt, clay) with organic matter distributed in surface of 0.5 to 1 meter, sand and gravel layer with clayey soil is up to 2 meters below. Groundwater table may be distributed -1.5m to -2.0m below the ground surface.

Second layer: Excellent aquifer with high permeability. It is composed of sand and gravel.

Third layer: Good aquifer. It is composed of sand and gravel with clayey soil. Its permeability will be high but lower than second layer. The lens of clayey soil may be distributed because of the sedimentation in old river backwater or pool.

Bedrock: It is composed of sandstone and slate of Devonian Period in Paleozoic Era (before 400 million years ago approximately) and basically impermeable excluding fissure or weathered zone.

Result

According to the electrical resistivity survey, the 2nd and 3rd layers are aquifers in the Upper Water Source, because of the high permeability of these layers.

### 3) Proposed Well Location

The new wells should be constructed with a spacing of more than 500 meters on average. The new well locations should be arranged on the basis of the distribution of existing production wells and the results of electrical resistivity survey. These are shown in Figure 2-7.

### 4) Number of Wells and Pumping Yield

The North Mountains of Tuul River are designated as the Terelj Natural Reserve Area. The proposed new wells will be located in the flood plain of Tuul River adjacent to Terelj Natural Reserve Area. This area was will be included Terelj Natural Reserve Area in 2004 because of its scenic beauty and native vegetation. Mongolian Environmental Law regulates excessive decline of groundwater table, because it may damage the native vegetation in the flood plain of Tuul River. MNE requires that this groundwater development project comply with the law, which prohibits excessive decline of groundwater table.

Consequently, groundwater development will be planned to avoid the excessive drawdown to keep the groundwater table with around minus 2 meters from the static groundwater table. The number of wells that will be necessary to withdraw the groundwater of 18,000 cu.m/day while limiting the drawdown, was determined based on the pumping drawdown and interference with the other wells using the transmissivity of existing production wells.

#### a. Pumping Drawdown

Drawdown by pumping is as follows:

Table 2-11 Pumping Drawdown

| Well number*[1] | Q: Pumping yield (cu.m /day/well) | Δ hr: Drawdown Tave.=921 (cu.m /day/m) |
|---|---|---|
| 12 | 1636 | 2.33 |
| 14 | 1385 | 1.96 |
| 16 | 1200 | 1.68*[2] |

*[1]: Pumping yield is calculated except for one stand-by well.
*[2]: Example;

$$\Delta\ hr = \frac{2.3Q}{2\pi T}\log\frac{re}{rw} = \frac{2.3x1200}{2x3.14x921}\log\frac{834}{0.25} = 1.68\text{m}$$

Where:

Δhr : drawdown (m), T: transmissivity (cu.m /day/m), Q: pumping yield (cu.m /day),

rw：screen diameter (m), $re = \sqrt{\frac{Q}{\pi R}}$ ：interference (m), R：recharge rate ($m^3/m^2$/day)

（T： Tave.=921(cu.m /day/m); average transmissivity of existing 39 production wells)）

R：precipitation 200mm (0.00055 cu.m /$m^2$/day)

#### b. Drawdown by Well Interference

Drawdown by well interference will be estimated using Jacob’s modified equation in one year as follows:

Table 2-12 Drawdown by Well Interference (m)

| Well number* | Q: Pumping yield (cu.m /day/well) | Least well distance (including existing wells) (m) | s: drawdown Tave.=921 (cu.m /day/m) S=0.10 |
|---|---|---|---|
| 12 | 1636 | 500 | 0.48 |
| 14 | 1385 | 500 | 0.41 |
| 16 | 1200 | 500 | 0.35 |

*: Pumping yield is calculated except for one stand-by well.

Jacob's modified equation

$$s = \frac{0.183Q}{T}\log\frac{2.25Tt}{r^2 2S}$$

where:

s: interference drawdown (m), Q: pumping yield (cu.m /day)、t: pumping duration (100 days), T: transmissivity (cu.m /day/m)、S: specific yield (non dimension) , r: distance between well (m)

Total groundwater drawdown with pumping and interference is as follows:

- In the case of 14 wells (operating simultaneously 13 wells); 2.37m (=1.96+0.41)
- In the case of 16 wells (operating simultaneously 15 wells); 2.03m (=1.68+0.35)

Consequently, 16 wells (including one stand-by well) are recommended to withdraw the required groundwater of 18,000 cu.m /day. Each pumping yield will be 1,200 cu.m /day/well.

## 5) Well Design

### a. Well Depth

The depth to bedrock is estimated to be 30 to 40 meters beneath the ground surface, and the thickness of aquifer is estimated at 25 to 30 meters in the vicinity of survey points of E1 - E3 and E-15 located in the upstream reach of the project area based on the results of electric resistivity testing and field reconnaissance.

The other area is also estimated in the same manner as follows:

E1 - E3 and E15 in the upstream reach of the project area

- depth to bedrock: 30 to 40 meters
- thickness of aquifer: 25 to 30 meters

E4 - E5 and E7 in the middle reach of the project area

- depth of bedrock: 45 to 50 meters
- thickness of aquifer: 40 meters

E8 - E11 in the middle stream reach of the project area

- depth of bedrock: 30 to 35 meters
- thickness of aquifer: 25 to 30 meters

E12, E13 in the downstream reach of the project area

- depth of bedrock: 25 meters
- thickness of aquifer: 22 meters

Consequently, well depth is defined as follows:

Type A: N14-N16, total 3 wells, depth is 30 meters, aquifer thickness is 22 meters

Type B: N1-N6 and N10-N13, total 10 wells, depth is 35 meters, aquifer thickness is 25 - 30 meters

Type C: N7-N9, total 3 wells, depth is 45meters, aquifer thickness is 40 meters

**b. Casing Diameter and Well Diameter**

A submersible motor pump with the capacity of 1,200 cu.m/day (pump discharge diameter of 100mm) requires a well diameter greater than 250 millimeters. The casing diameter is also specified as 250 millimeters for a pumping yield of less than 1,500 cu.m/day by the [Waterworks Facilities Standards]. Consequently, the casing diameter will be 250 millimeters and well diameter (drilling diameter) will be 400 millimeters, which will be completed with a gravel pack.

**c. Specification of Casing and Screen**

The casing will be steel pipe, which is the same material as the existing production wells. The screen will be wire-type with V-slit (wire diameter is 4mm and slit width is 1.5mm).

**d. Examination of Screen Length**

In general, the required screen length ranges from 1/3 to 1/2 of thickness of the aquifer. If screen length is shorter than this length, high vertical groundwater flow into the screen is generated and large head-loss and drawdown occurs.

Consequently, screen length is determined on the consideration of aquifer thickness (Ta) as follows:

Type A: (Ta : 22 m); required range 7.3 m – 11 m, applied length 11 m

Type B: (Ta: 25 m to 30 m); required range 8.3 m – 15 m, applied length 11 m

Type C: (Ta: 40 m); required range 13.3m – 20 m, applied length 16.5m

**e. Verification on Groundwater Inflow Velocity into the Screen**

Groundwater inflow velocity into the screen is required to be less than 1.5cm/sec to avoid inflow of sand fines. The open area of screen is 27.3% of the total area. The inflow velocity is computed as follows:

$v = Q/A = 1{,}200 / (0.25 \times 3.14 \times 0.273 \times 11 \text{ to } 16.5) = 509 \text{ to } 339\text{m/day} = 0.59 \text{ to } 0.39 \text{ cm/second}$

where: screen length: 11m to16.5m, and

Q; pumping yield: 1,200 $m^3$/day

The inflow velocity is less than 1.5cm/second for screen lengths ranging from 11 to 16.5 meters.

**f. Well Specifications**

The well specifications are shown in the following table.

Table 2-13 Well Specifications

| Proposed well name | Well depth (m) | Well diameter (mm) | Casing diameter (mm) | Screen length (m) | Applied type |
|---|---|---|---|---|---|
| N-1〜N-6<br>N-10〜N-13 | 35 | 400 | 250 | 11 | B |
| N-7〜N-9 | 45 | 400 | 250 | 16.5 | C |
| N-14〜N-16 | 30 | 400 | 250 | 11 | A |

#### 6) Well Contingency

According to the results of electrical resistivity survey, the aquifer will be composed of sand and gravel with clayey soil. Clayey soil may be distributed in lenses. However, electrical resistivity testing cannot detect the distribution of these clayey soil lenses in detail.

Referring to the JICA funded project of groundwater development in Central Water Source in 1999, 19 wells had been constructed and two of the wells could not get the designed pumping yield. Testing was conducted at each drilling point before well construction and screens were installed at the ideal place by the result of electric loggings. However, designed pumping yield could not be achieved for two of the 19 wells.

It is probable that clayey soils might be distributed at the screen points, which were determined by the result of both electric prospecting and electric logging. Two new wells were constructed within ten meters from original points and the designed pumping yield was achieved.

The Upper Water Source of the Project has the same geologic and aquifer characteristics as that of the Central Water Source. Consequently, well contingency will be expected to be 10% for the groundwater development in the Upper Water Source applying the same failure rate of Central Water Source development (2/19=10.5%).

### (2) Well pumps

#### 1) Capacity and the Number of Units

- Proposed amount of water intake : 18,000 cu.m /day
- The number of wells : 16 sets (include one stand-by)
- Pump capacity :18,000 cu.m /day x 1 / 15 sets
  =1,200 cu.m /day=50 cu.m / hr / set
- The number of well pumps : 16 sets (including installation and one stand-by)

#### 2) Type of Well Pumps

- New well pumps shall be submerged motor pumps which is the same type as existing well pumps
- These well pumps and related facilities such as control panel, electricity equipment are installed inside the building to prevent from freezing in winter and for easy maintenance of the pump facilities.

#### 3) Total Pump Head

Based on basic study, the necessary total head for well pumps is as follows:

H=actual pump head + total pipe head loss

=(High Water Level at receiving tank in transmission pump station – Low Water Level at each well ) + Raw water pipe head loss + Pipe head loss round pump = 62 to 65 m

In this project, the specification of pumps with 65 m in total head will result in selection of the same unit for all wells and will make the exchangeability of the pumps possible.

### 4) Remote Control System

The engineers in transmission pump station instruct caretakers assigned to each existing well pumping station through walky-talky to turn pumps ON or OFF. Considering the following, pump ON-OFF operation at the proposed well pump stations shall be performed through remote control manipulated by the engineers in transmission pump station. The proposed operational relationship in Upper Water Source Area including Zavsariin reservoir is shown below:

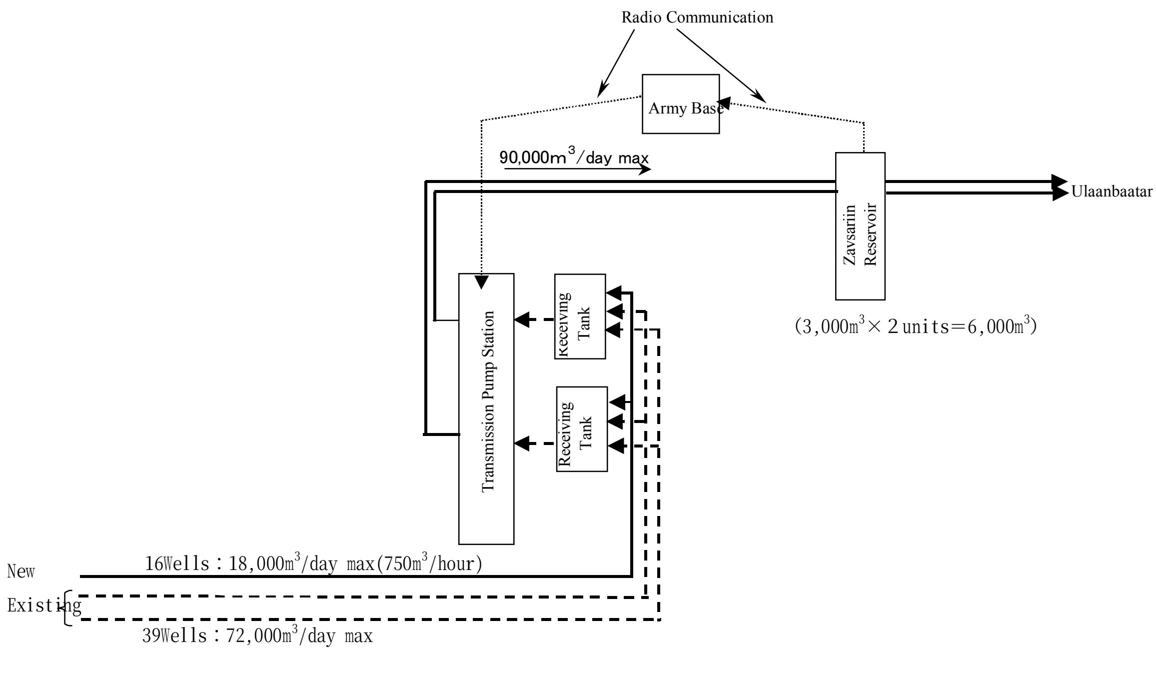
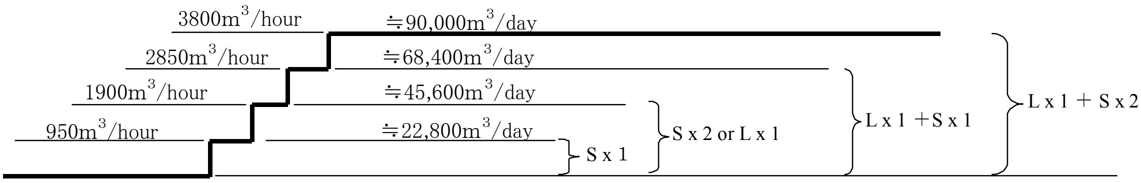



Figure 2-2 Schematic System Drawing

Operational Arrangement

1) Water level in Zavsariin reservoir is measured and transmitted to Upper Water Source transmission pump station through radio communication in every five minutes.
2) According to this water level, manual ON-OFF pump operation is conducted.
3) Pump operation number is also decided based on this water level.
4) When water level in the receiving tank is low, transmission pumps cannot be operated. Further, when water level becomes low, transmission pumps are automatically stopped. This means that necessary water volume is not always available.
5) Since the capacity of each of the two receiving tanks is 1,000 cubic meters which is relatively small, total water quantity pumped from well pump stations shall be equivalent to the specific transmission

water quantity.  Total transmission water quantity by pump operation combination is as follows:




Notes; S: Small
L: Large

6) By operation/suspension of one unit of small capacity pump, water quantity fluctuation of 950 $m^3$/hr occurs in transmission water quantity and said water quantity is equivalent to the well production flow from 12 to 13 existing wells (950÷75 $m^3$/hr).  By operation/suspension of larger pump, fluctuation quantity is doubled.
7) In case of existing well pump stations excluded from the scope of proposed remote control system, pump ON-OFF operation will be executed manually.  Caretakers instructed by engineers in concerned transmission pump station would go to well pump stations by horse to perform pump operation.  While proposed 16 wells will be operated by remote control system.

Necessity of Remote Control System

1) Operation of transmission pumps will be governed by the water level in Zavsariin reservoir.
2) This water level is also influenced by the distribution water quantity to the Ulaanbaatar, namely water consumption pattern.
3) Distribution water quantity fluctuation has several patterns according to season, climate, day of the week and hour of the day.  These patterns can be monitored through the operation of transmission pumps and be simulated based on the actual distribution quantity fluctuation through the years.
4) Hourly operation pattern for the well pump stations shall be established based on the predicted distribution water quantity fluctuation patterns.
5) While, water shortage or overflow might be occurred when pump ON-OFF operation is not conducted timely.
6) Introduction of remote control system to the proposed well pump stations will ease the pump operation and will increase the stability in water supply.  This system will enable intake flow control, ranging from 0 to 18,000 $m^3$/day, at the transmission pump station.
7) This system will work effectively, even in cases where access to the pump stations is not possible due to river flooding.

Remote Control System

Compared to a communication system using metallic cables, a radio communication system was adopted due to lower influence by current surges caused by the lightening. Outline and schematic drawing of the proposed communication system are as follows:

1) Assigning the transmission pump station to master station, the system is comprised of antenna, radio modem, radio device and two personal computers (PC). The operator through the operational image on PC screen will operate well pump stations.
2) Each well pump station will be local station, equipped with antenna, radio modem, radio device and programmable logic controller (PLC) which enables the communication with master station and pump operation.
3) Two radio frequency ranges were set for mutual communication between master station and local stations. Radio frequency ranges for voice communication were secured as well.
4) Poling system, cyclic communication system between master station and local stations, was employed to enable the mutual communication by one radio device at master station.
5) Upon setting these radio frequency ranges, approval from concerned radio administration offices shall be acquired during the detailed study.

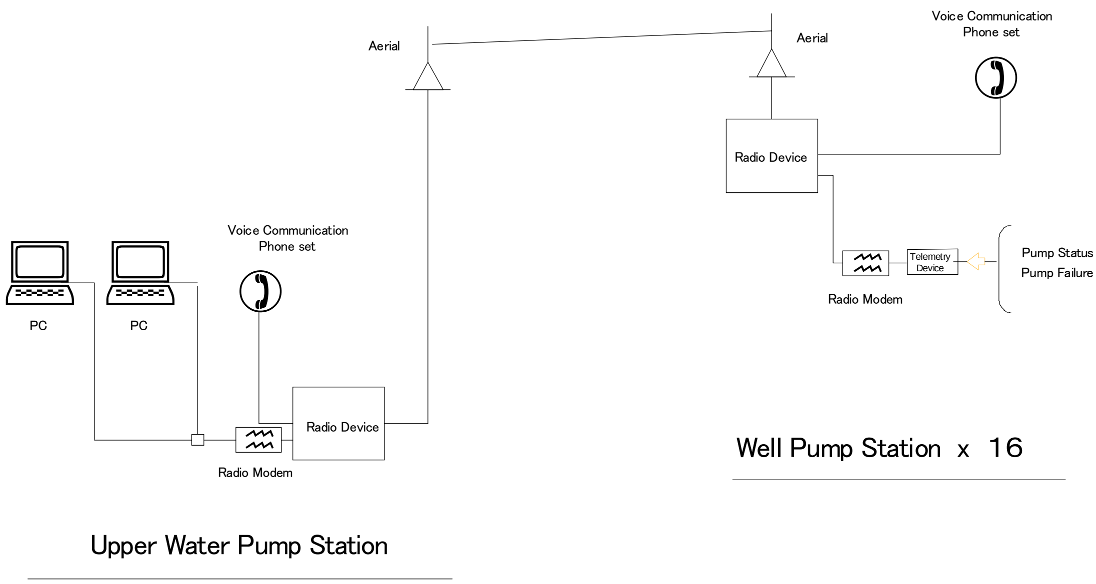



Figure 2-3 Proposed Remote Control System for Upper Water Source Area

The well pumps will be automatically stopped at the design low water level to prevent idle running.

### 5) Outline of Equipment

Table 2-14 Equipment Outline on Well Pump Station in Upper Water Source Area

| Name of Equipment and Building Materials | Specification | Quantity | Remakes |
|---|---|---|---|
| **[Mechanical Equipment]** | | | New |
| Well pumps | Submerged Motor Pump<br>Dia 100×50 cu.m /hr × 65m × 18.5kW | 16 units | Including one stand-by |
| Pump lifting Equipment | Manually Operated Chain Block with Geared Trolley: 1-ton | 3 sets | Use each pump station commonly |
| Indoor Piping / Valves | Installation in Indoor | 1 set | |
| **[Electric Equipment]** | | | New |
| Power Receiving Transformer | Oil Cooling Type<br>10kV／400V、50kVA | 16 sets | Including load switch (1-set), Arrester (3-sets) |
| Low-voltage Motor Control Devices with Panel | Indoor Wall-hanging Type, Steel Panel<br>18.5kW Motor With Star-Delta Starting Connection | 16 sets | |
| Water-level Detector Devices | Electrode Type | 16 sets | Detector for low-water level of well |
| Cable for Power and Control | | 1 set | |
| Local-station of remote control system | Antenna, modem of radio, radio, PLC (programmable logic controller) | 16 sets | New |
| **[Civil and Building]** | | | New |
| Building for well Pumps | | 16 | |

## (3) Raw Water Conveyance Pipe

### 1) Route for the Pipeline

The route for the new raw water conveyance pipe is shown in the plan view in "Drawing of Basic Plan Section 2-2-3". The raw water conveyance pipe consists of several jointed branch pipelines and branch off pipelines.

a. For the new well pumps, 16 well pumps are to be installed from N-1 to N-16 installed parallel near the site of existing well pumps from No-1 to No-10 (total existing number is 39 wells) on the south side of the Tuul River.

b. The main raw water conveyance pipeline will be parallel on the north side of the existing water pipeline.

The existing pipeline was installed in a trench and was covered by soil to prevent freezing during the winter months. The final height of soil cover was designed so that the ground surface will not be submerged during flooding, so that operation and maintenance can still be undertaken during floods.

In this project, the new main pipe will be placed underground parallel to the existing raw water conveyance pipe. The soil cover will be expanded to the north over the new pipeline. A utility pole inside the cover soil on the north side is established on the concrete pile. This utility pole to be transferred more to north to keep a distance of five meters or more from the cover soil due to road expansion.

### 2) Selection of Pipe Material

In this project, steel pipe is adopted, because the existing pipeline makes use of the steel pipe and no problems have occurred. Also, USAG has experience and equipment for repair and maintenance of the steel pipe.

### 3) Laying Depth of Water Pipeline

The new water pipeline will be installed below the freezing depth, similarly to the existing pipeline. The construction method used for the existing pipeline was first excavating to the desired elevation and laying the pipe with cover soil to have a position deeper than freezing depth. The total thickness of the soil cover was more than 3.5 m in depth.

In this project, the depth will be 3.5 m, based on inspection of the existing works and knowledge of the construction method. However, the pipe at river crossing will be laid in an outer pipe with thermal insulation and will be covered by 1.5m thickness soil to protect against freezing. The outer pipe will be wrapped by concrete to protect the pipeline against scouring. This method will reduce the time required to complete the installation.

### 4) Construction of Stormwater Drainage Pipe

There is a stormwater drainage pipe under the existing access road over the pipeline to drain stagnant stormwater and increased stormwater flow during rainy season. In this project, a new pipeline the same size as the existing pipeline will be installed.

**a. In the vicinity of existing No.9 well**

Concrete Pipe 1,000 mm in diameter x 2 pipes
Concrete Pipe 600 mm in diameter x 1 pipe

**b. In front of Transmission Pump Station**

Steel Pipe 1,500 mm in diameter x 1 pipe
Steel Pipe 600 mm in diameter x 3 pipes
Concrete Pipe 1,000 mm in diameter x 2 pipes
(Off site 600mm x 2 pipes)

**c. In the vicinity of new No.4 well**

RC 1,000 mm in diameter x 2 pipes

At the near new well site, there are some small-scale slopes that may cause stream during the rainy season by stormwater runoff. In this project, construction of new drainpipe, concrete pipe 1,000 mm in diameter x 1 pipe is required at intervals of 100 m.

### 5) Design for Raw Water Conveyance Pipe

The drawings of the raw water conveyance and network calculations were prepared. The details of the raw water conveyance pipe that will be installed in this project are shown in Table 2-15.

Table 2-15 Summary of Raw Water conveyance pipe

| Pipe Diameter (mm) | Total length (m) |
|---|---|
| 500 | 750 |
| 400 | 4,970 |
| 300 | 500 |
| 250 | 960 |
| 200 | 1,060 |
| 150 | 4,345 |
| Total | 12,585 |

Gate valves will be installed midway along the raw water conveyance line for maintenance of the pipeline.

### 6) Method of Pipe Connection into Receiving Tanks

There are two existing concrete receiving tanks at the transmission pump station. Raw water from the wells flows into the tanks through three existing raw water transmission pipes. For the installation of new pipelines to connect to the existing tanks, the connection method to be used for receiving water shall be the same as existing method, which is burial below the freezing depth and is entering through the side wall of the concrete tank.

## 2-2-2-3 Plan on Transmission Pump station in Upper Water Source

### (1) Basic Policy

### 1) Present State

The transmission pump station to supply water in the city is located about 35 km east of the central city. There are 39 existing wells at the Upper Water Source. The water pumped to the transmission station is sent to Zavsariin reservoir and supplied to the city by gravity. The transmission station has six transmission pumps including three sets of stand-by pumps. The condition of the pumps based on observations made during the site visit and a review of operating data are presented in Table 2-16.

Table 2-16 Present Condition for Upper Water Source Transmission Pump

| | Number of Pump | Specification | The Date of Manufacture | Condition of pump Operation etc. |
|---|---|---|---|---|
| Existing | 1 | Dia 350/250×1000 cu.m /hr×180m×630kW | 1990 | ・waiting |
| | 2 | Dia 350/250×1000 cu.m /hr×140m×500kW | 1990 | ・under operation |
| | 3 | Dia 350/250×1000 cu.m /hr×140m×500kW | 1990 | ・waiting |
| | 4 | Dia 350/250×1000 cu.m /hr×140m×500kW | 1990 | ・waiting |
| | 5 | Dia 350/250×1000 cu.m /hr×140m×500kW | 1990 | ・pause<br>・deformation of shaft, necessary to replace |
| | 6 | Dia 350/250×1000 cu.m /hr×180m×630kW | 1990 | ・waiting (alternate operation with No.2) |
| | Comments: The pump efficiency decline because the abrasion of pump Impeller, bearing unit, degradation of seal and leakage of water, are in all of each pump, although it is possible an operation in all of 5 units except for No. 5. | | | |

According to operating data during New Year and Naadam, two of the pumps are operated at a time because of high water demand. Only one pump is operated under normal water demand for the following reasons:

- Under normal water demand, the water is delivered to the city directly through a by-pass line without using the Zavsariin reservoir. When two or more pumps are operated, the water pressure inside the pipeline is high causing breakages in the pipeline.
- The Zavsariin reservoir is used to control delivery pressure and store the water. However, the reservoir has not been used after one month completion because the water overflowed from the top the tank, due to the lack of inflow and pressure controls. This resulted to freezing a main road along the downstream area. USAG considers this to be a facility malfunction.

To resolve this issue, improvements are being implemented under World Bank project that will be completed in December 2003. World Bank improvement program is developing a 72,000 cu.m/day water supply that is sufficient capacity of existing 3-pumps as follows.

a. Installation of pressure reducing valves and flow meters in the pipeline to enable the use of the Zavsariin reservoir
b. Improvements of the system to be more effective such as:
    - Installation of a pressure gauge for water level detection
    - Installation of a device to transmit data to the pump station by radio through military complexes in Nalaih.
c. Install surge control valves on the pump delivery header pipe to prevent the water hammer

The flow chart of existing transmission pump station is shown in the Figure 2-4.

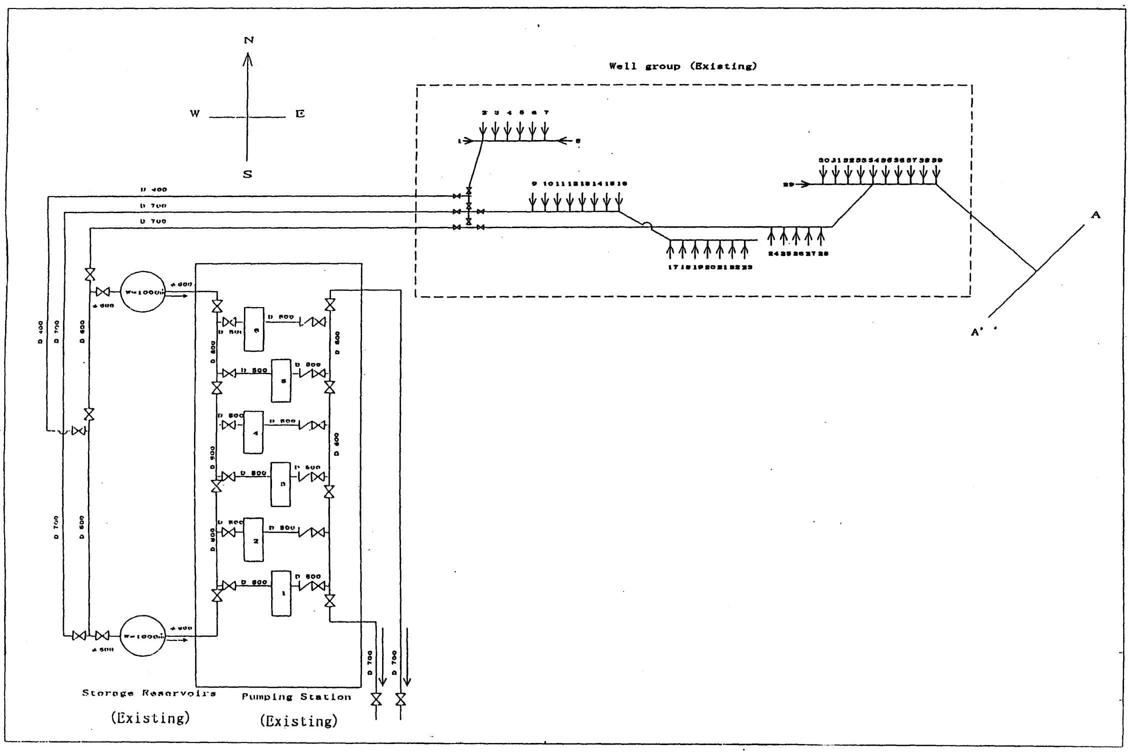



Figure 2-4 Flow Chart of Existing Transmission Pump Station and Intake Facility in Upper Water Source

### 2) Issues

The project issues, as a result of field inspection, are as follows.

- Decline of pump performance. Based on the results of the pump performance test, the actual pump capacity is decreased, a drastic retrenchment of total pump discharge head. For example pump No.2 discharge head is 90 m compared to the design discharge head of 140 m, and pump No.6 discharge head is 115 m compared to the design discharge head of 180 m. The decreased capacity is insufficient for required total pump head of 140 m in this project.
- Deterioration of pump parts and repair difficulty. Deterioration of shaft bearings and seals, leakage of water. These parts are not available in local market.
- Deterioration of valves. Leakage of water from seals, malfunction of check valves, etc.
- Deterioration of electrical equipment and repair difficulty. Deterioration of middle-voltage control parts and low-voltage control parts, local control parts and monitor. These parts are not available in local market.
- Increase in the electric power expense. Electric power expense is high due to decline in the pumps efficiency. Replacement of existing pumps with pumps made in Japan that can save about 30% of the electrical power cost in comparison with the present condition.

This rehabilitation project consists of replacing six pumps and related valves and electrical equipment, excluding power receiving equipment. However, the pump capacity and number of units shall be added in this project to meet future water demand. The new 16 well pumps will be able to operated automatically based on remote control from the Upper Water Source transmission pump station.

## (2) Plan for Transmission Pumps

### 1) Design Transmission Flow

The design daily maximum flow rate for the transmission pumps is 90,000 cu.m /day.

### 2) Pump Capacity and the Number of Units

There are six pumps, including three standby pumps, at the existing transmission station. During normal operation, only one or two pumps have been operating with the bulk of the water bypassing the Zavsariin reservoir and being sent directly to city. This is to avoid creating high pressure in pipeline.

World Bank improvement program has been started without the rehabilitation of transmission pumps. After the review of World Bank project and inspection of the existing pumps in this project, it is recommended that two small pumps and a large pump should be operated, with stand-by pumps. This is recommended for the following reasons.

- Reducing the number of pumps would reduce maintenance costs and simplify operation.
- The recommended pump configuration would be better suited to satisfying varying water demand.
- The recommended pump configuration would reduce electrical power costs because of the increase pump efficiency.

Specifications and capacity of pumps are as follows:

- Small pump:
  90,000 cu.m/day x 1/ (1+1+2) x 1/24 = 937.5 cu.m/hr, 3 pumps @ 950 cu.m/hr/pump (including one standby)
- Large pump:
  950 cu.m/hr x 2 = 1,900 cu.m/hr, 2 pumps @ 1,900 cu.m/hr/pump(including one stand-by)

### 3) Total Pump Head

The necessary total discharge head for the transmission pumps is as follows:

H = actual pump head + total pipe head loss
= (High Water Level at transmission pipe – Low Water Level at receiving tank in transmission pump station) + total transmission pipe head loss + pipe head loss round pump = 140 m

The total discharge head necessary for the transmission pumps is 140 m.

### 4) Operation Mode

The pumps will be operated manually, with operation controlled based on a water level signal from the Zavsaariin reservoir. The transmission pumps will stop automatically when a low water level occurs at the receiving tank in the transmission pump station.

### 5) Summary of Facilities

Table 2-17 Summary of Equipment after Replacement on Transmission Pump Station

| Name of Equipment and Building Materials | Specification | Quantity | Remarks |
|---|---|---|---|
| **[Mechanical Equipment]** | | | |
| No.1～3 Transmission Pumps | Horizontal Double Suction Centrifugal Pump Dia 350/200×950 cu.m /hr×140m×630kW | 3-sets (Including one stand-by) | Replacement |
| No.4,5 Transmission Pumps | Horizontal Double Suction Centrifugal Pump Dia 450/250×1900 cu.m /hr×140m×1050kW | 2-sets (Including one stand-by) | Replacement |
| Boiler Feed water Pumps | Single Suction Centrifugal Pumps 80 cu.m /hr×22kW | 2-sets (Including one stand-by) | Replacement |
| Floor Discharge Pumps | Submerged Pumps 0.5 cu.m /min×2.2kW | 2-sets (Including one stand-by) | Replacement |
| Pipe and Valves | | 1-lot | Replacement |
| **[Electric Equipment]** | | | |
| Middle-Voltage Power Receiving Panels | Self-Standing Indoor Type Steel Panels 7.2kV、20kA、VCB | 2-sets | Replacement |
| Middle-Voltage, Bus-Tie panel | Self-Standing Indoor Type Steel Panel 7.2kV、20kA、VCB | 1-set | Replacement |
| Middle-Voltage Motor Starters Panels | Self-Standing Indoor Type Steel Panel 7.2kV、VCS, 630kW Reactor Starting for Motor | 3-sets | Replacement |
| Middle-Voltage Motor Starters Panels | Self-Standing Indoor Type Steel Panel 7.2kV、VCS 1050kW Reactor Starting for Motor | 2-sets | Replacement |
| Middle-Voltage Switch Panels | Self-Standing Indoor Type Steel Panel 7.2kV、20kA、VCB | 2-sets | Replacement |
| Low Voltage Power Receiving Equipment Panels | Self-Standing Indoor Type Steel Panel | 1-set | Replacement |
| Low Voltage Switch Panels | Self-Standing Indoor Type Steel Panel | 4-sets | Replacement |
| Local Controls Panels | Wall-Hanging, Indoor Type Steel Panel | 7-sets | Replacement |
| Operation Monitoring Equipment Panel | Desk, Indoor Type Steel Pane | 1-set | Replacement with uninterruptible Power Supply Device |
| Flow Meters for Transmission Pipe | Supersonic Wave Type Dia 700 | 2-sets | Replacement |
| Water Level Gauges for Reservoir | Supersonic Wave Type | 2-sets | Replacement |
| Sending Devices of pressure for Transmission Pipe | Water use | 2-sets | Replacement |
| Detectors of Water Temperature for Transmission Pipe | Resistance-type Temperature Measuring | 2-sets | Replacement |
| Power and Control Cable | | 1-lot | Replacement |
| Central station of remote control system | Antenna, modem of radio, radio, PC (personal computer ) 2sets | 1-lot | New |

## (3) Plan for Existing Transmission Pipeline

### 1) Briefing

An analysis of the water hammer protection measures and pipe thickness of the existing pipeline from the transmission pump station to Zavsaariin reservoir was performed.

## 2) Conditions for Discussion

### a. Specification of Transmission Pumps

Dia 350 / 200 x 950 cu.m/hr x 140 m x 630 kW x 3 pumps (including one stand-by)

Dia 450 / 250 x 1,900 cu.m/hr x 140 m x 1050 kW x 2 pumps (including one stand -by)

### b. State of Existing Transmission Pipe Line

(See pressure grade line along pipeline)

Point A: at transmission pump station

Point C: at highest point of transmission pipeline

Point E: at Zavsaaiin reservoir

Transmission pipeline between Point A and Point C:

Dia 700 mm x 2 pipes, thickness t=8.0 mm, L=16,032 m

Transmission pipeline between Point C and Point E:

Dia 600 mm x 2 pipes, thickness t=8.0 mm, L=13,071 m

## 3) Water Hammer Measures (surge control)

Water hammer occurs when all of the pumps stop suddenly, such as in the event of a power failure. Water hammer can damage the pipeline and other equipment. To prevent water hammer from occurring, it is recommended that the surge vessel be installed within the new building at the transmission pump station. This approach is recommended because of ease of construction and maintenance. Locating the vessel within the new building will avoid freezing that may otherwise occur.

### a. Flywheel Method

The weight and diameter of flywheel is decided by capacity of induction motor. It is necessary to combine flywheel and another method because this method cannot prevent the force of water hammer by itself. However, the existing pump room is not big enough to install the pump with flywheel, the total length available is 3 m. Therefore construction of a new building would be required.

### b. One-way Surge Tank Method

One option would be to locate three surge tanks at high points along transmission pipeline. However, it would be difficult to protect the surge tanks from freezing and to obtain an approval to construct the tanks from the Department of Environment.

### c. Surge Vessel Method

Construction of a new building for a surge vessel near the existing transmission pump room is the best option, because of ease of operation and maintenance. The replacement of existing small air valve with large air valve is required to prevent negative pressure created by surge at highest point on the transmission pipeline.

Table 2-18 Outline of Equipment for Improvement on Existing Transmission Pipeline

| Name of Equipment and Building Materials | Specification | Quantity | Remarks |
|---|---|---|---|
| **[Mechanical Equipment]** | | | |
| Surge Vessels | Steel Pressured Vessel Tank, Capacity: 20 cu.m, Dimension: Dia 2.0 m x H 6.7 m | 2-tanks | New Connection Dai:300 |
| Air Compressor | Pressure Switch, 11 kw | 2-sets | New |
| Chain Block for Lifting Equipment | Manually Operated Chain Block with Geared Trolley: 1-ton | 1-set | New |
| Air-Valve for Transmission pipe line | Air Release Valve, Dia150 mm Maximum air inflow rate: about 43 cu.m / min. | 4-sets (including 2-sets stand-by) | Replacement, installation at the highest transmission pipe line |
| Pipe and valves | | 1-lot | New |
| **[Electric Equipment]** | | | |
| Low-voltage motor starter Panel | Indoor Wall-Hanging Type, Steel Panel, for air Compressor | 1-set | New |
| Water Temperature Detector Devices | Resistance type Water Temperature Measuring | 2-sets | New |
| Cable for Power and Control | | 1-lot | New |
| **[Civil and Building]** | | | |
| Serge Vessel Building | | 1-ridge | New |

### 4) Pipe Thickness for Existing Transmission Pipeline

The required minimum thickness of the transmission pipeline was calculated based on the maximum pressure in the pipeline, and the allowable stress.

#### a. Conditions for Discussion

The pipe thickness for existing transmission pipeline is 7 mm excluding 1 mm allowance for corrosion. The allowable stress of existing pipe is 100 $KN/mm^2$.

#### b. Results

The hoop stress against maximum inner pressure on transmission pipeline at point from A to C:

68.65 KN/mm2 < 100 KN/mm2

The hoop stress against maximum inner pressure on transmission pipeline at point from C to E:

66.00 KN/mm2 < 100 KN/mm2

Hence, the existing pipe thickness is sufficient to withstand the maximum pressure.

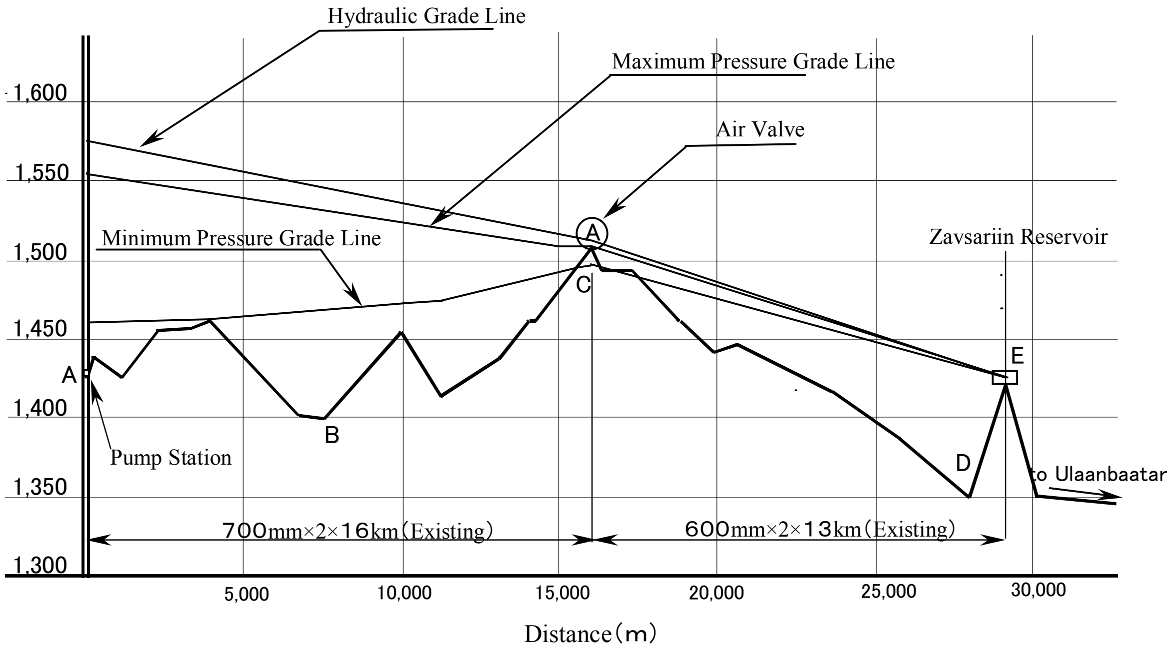



Figure 2-5　Pressure Grade Line on Transmission Pipe Line

### 2-2-2-4 Plan For The Central Water Source Distribution Pump Station

#### (1) Basic Policy

The amount of water distributed in the service area from the Central Water Source Distribution Pump Station is about 100,000 cu.m/day, accounting for more than 50% of the total supply within the city. The central distribution pump station located south of the central service area is the key pump station. This pump station is efficient due to the short distribution pipeline and close proximity to the service area. However, the existing pump is old and inefficient. In this project, replacement of pumps within the pump station is necessary.

Seven distribution pumps exist within the central pump station. Five out of the seven pumps were replaced during the last grant aid project completed in 1999. The other two pumps were not replaced since they were still in good condition at the time JICA reported in 1997. In this project, two pumps need to be replaced as shown in "new facility" where the large pumps are installed.

The condition of existing pumps within central pump station is shown in Table 2-19 and specified the number of pump as existing in the station.

- Old facility (installed smaller pumps): use regularly 3 pumps + one for stand-by
- New facility (installed larger pumps): use regularly 2 pumps + one for stand-by

Table 2-19 Condition of Central Distribution Pump Station

| Name of Facility | Pump Number | Specification | Year of Manufacture | Remarks |
|---|---|---|---|---|
| Old Facility | 1 | Φ300/250×630 cu.m /hr×90m×220kW | 1999 | Under operation (No.1,2,3,4 alternately) |
| | 2 | Φ300/250×630 cu.m /hr×90m×220kW | 1999 | Waiting |
| | 3 | Φ300/250×630 cu.m /hr×90m×220kW | 1999 | Under operation |
| | 4 | Φ300/250×630 cu.m /hr×90m×220kW | 1999 | Waiting |
| New Facility | 5 | Φ500/300×2000 cu.m /hr×100m×800kW | 1985 | ・Waiting (No.5,6,7 alternate operation)<br>・inefficient due to spoiled seal/ bearing/ abrasion of pump impeller |
| | 6 | Φ450/250×2000 cu.m /hr×100m×750kW | 1999 | Under operation |
| | 7 | Φ500/300×2000 cu.m /hr×100m×800kW | 1985 | ・Waiting (No.5,6,7 alternate operation)<br>・inefficient due to spoiled seal/ bearing/ abrasion of pump impeller |

Note [shaded] : Replaced by grant aid project in 1999

Two pumps were operating at the Old Facility and one pump was operating at the New Facility during the site inspection. However, based on operating data, three pumps are operated at the Old Facilitiy and two pumps are operated at the New Facility to meet maximum water demand per hours during New Year and Naadam. The existing central distribution pump station and well pumps are shown in the Figure 2-6.

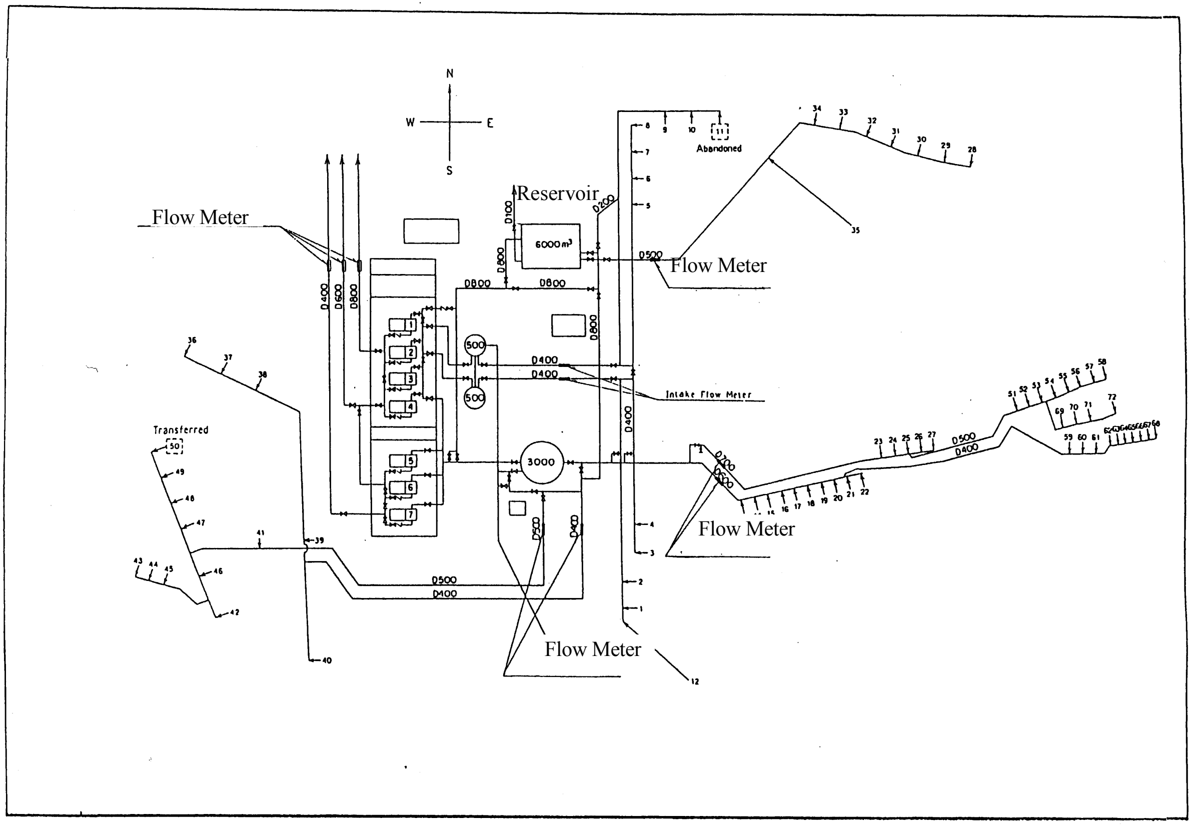



Figure 2-6 The existing Central Water Source distribution pump station and well pumps

The five pumps replaced by the grant aid project operate properly. The other two pumps, No-5 and No-7, need to be replaced because of the following problems.

- Decline in performance:
  - Based on the results of the field inspection, the performance loss of No-5 is 20% and the performance loss of No-7 is 25%.
- High energy cost:
  - The efficiency of the pumps had declined compared with No-6 that was replaced by grant aid project. Running the old pumps costs more than 20% than the new pumps.
- Deterioration of pump parts and maintenance difficulty:
  - Deterioration of shaft bearings and seals, the damage of axis, and leakage of water. Parts for these pumps are not available in local market.
- Deterioration of valves:
  - Leakage of water from seals, malfunction of check valve, etc.
- Deterioration of electrical equipment and maintenance difficulty:
  - Deterioration of No-5 and No-7 electric parts and the control panels. Parts for this equipment are not available in local market.

In this project, two out of the seven pumps will be replaced along with related valves and electrical equipment, excluding power receiving equipment.

### (2) Plan for Central Pump Station

#### 1) Pump Capacity and the Number of Units

- Capacity: 2,000 cu.m/hr (the same as existing design flow)
- Discharge head: 100 m (the same as existing pumping head, No-6, to meet parallel operation)
- Number of units: 2-pumps, (No-5 and No-7 to be replaced)

#### 2) Operation Mode

- Manual operation
- Pumps stop automatically when low water level detected at receiving tank

#### 3) Summary of Facility

Table 2-20 Summary of Equipment List to be Replacement on Central Water Source Pump Station

| Name of Equipment | Specification | Quantity | Remarks |
|---|---|---|---|
| **[Mechanical Equipment]** | | | |
| No-5 and No-7 Transmission Pumps | Horizontal Double Suction centrifugal Pump Dia.450/250x2000cu.m/hrx100mx750kW | 2-sets | Replacement |
| Pipe and valves | | 1-lot | Replacement |
| **[Electric Equipment]** | | | |
| Middle-voltage motor starter Panels | Self-Standing, Indoor Type Steel Panel 7.2 kV, VCS 750 Kw Reactor Staring for Motor | 2-sets | Replacement |
| Low-voltage Switch and Panel | Self-Standing, Indoor Type Steel Panel | 1-set | Replacement |
| Local Control Panels | Wall-Hanging, Indoor Type Steel Panel | 2-sets | Replacement |
| Emergency stop Panels | Wall-Hanging, Indoor Type Steel Panel, for pump operation | 2-sets | Replacement |
| Cable for Power and Control | | 1-lot | Replacement |

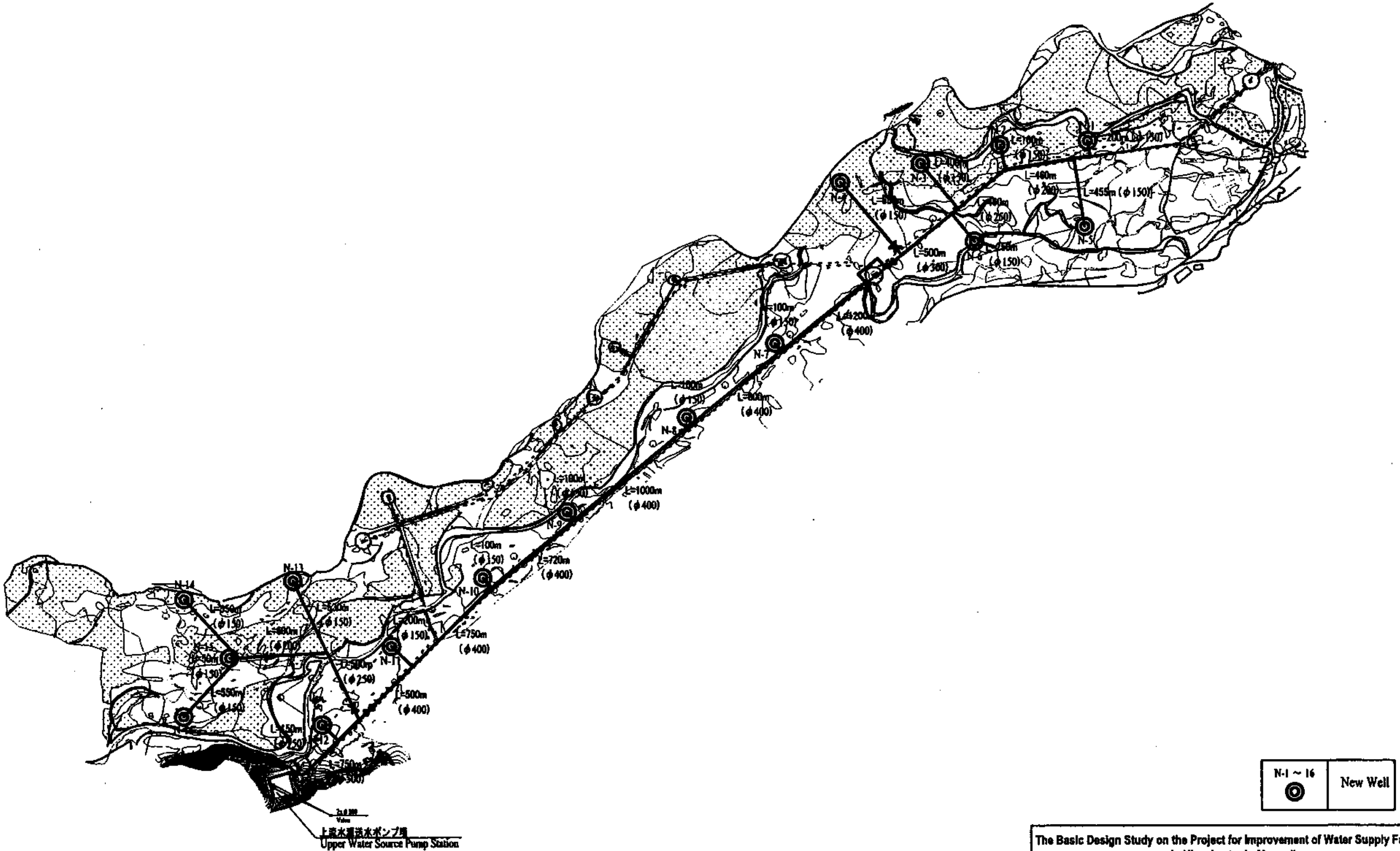
### 2-2-2-5 Plan on Offering for Device and Material

To prevent against freezing at each well pump station in Upper Water Source Area, an electrical heater is placed on the wall in the well house. The electrical power consumption is 6 kW per pump station, which is high value and is equivalent to 14 to 27% of total electrical power consumption for each pump station. To reduce electrical power consumption, a direct pipe heating system adopted in the last grant aid project should be included in this project.

In this project, a total of 55 pump stations are required. Materials for installation of the pipe heat system are as follows.

Type: Pipe heat and lagging materials to prevent against pipe freezing
Electrical power consumption: about 0.3 kW per pump station
Quantity: Total 55 sets
(including existing 39-pump stations and new 16-pump stations)

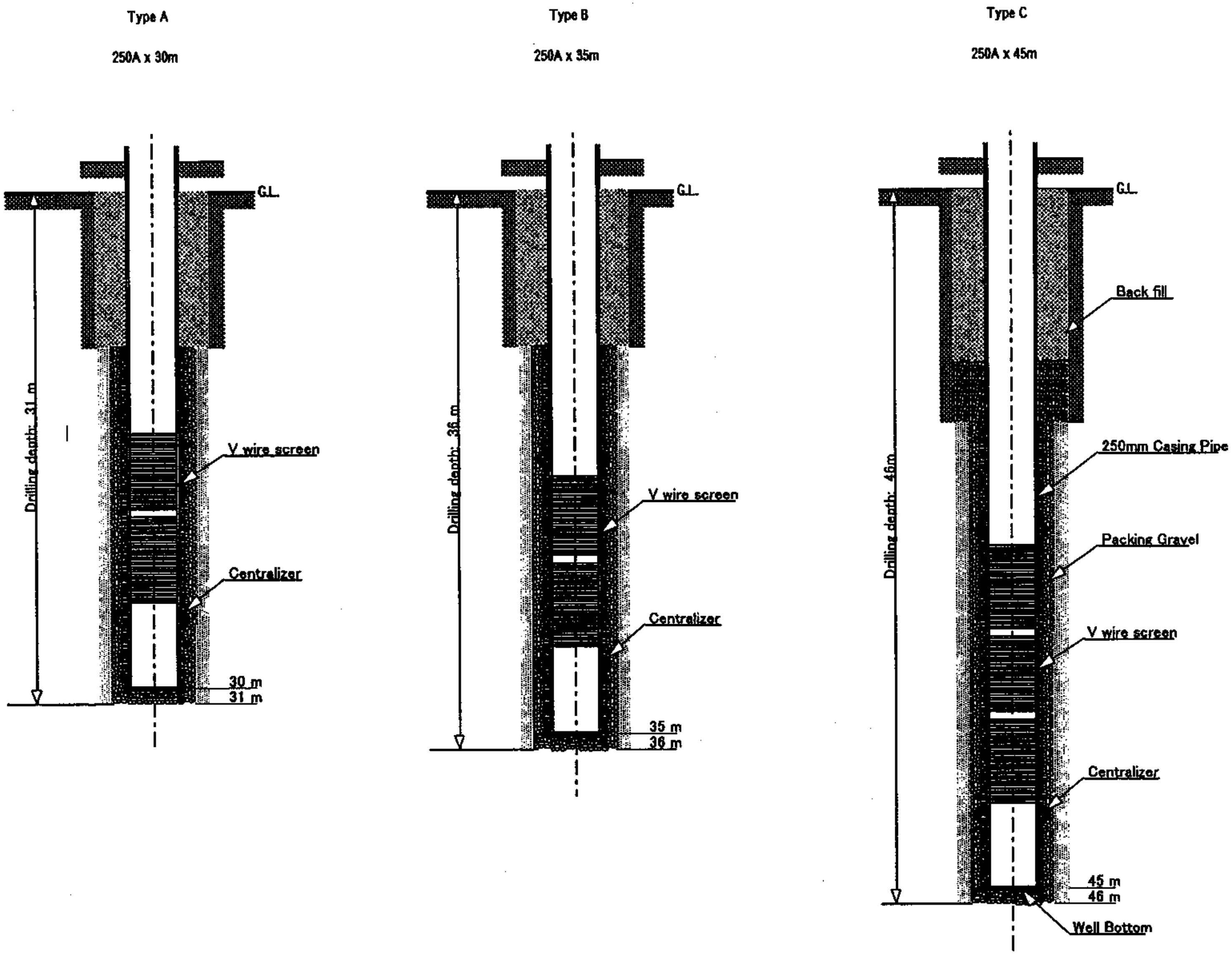
### 2-2-3 Basic Design Drawings




The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia

モンゴル国ウランバートル市給水施設改善計画基本設計調査

| | | |
|---|---|---|
| Upper Water Source Wells and Conveyance Pipe Location<br>図3－7 上流水源井戸及び導水管平面図 | Scale: | NONE |
| | Drawing No. | 2-7 |




33

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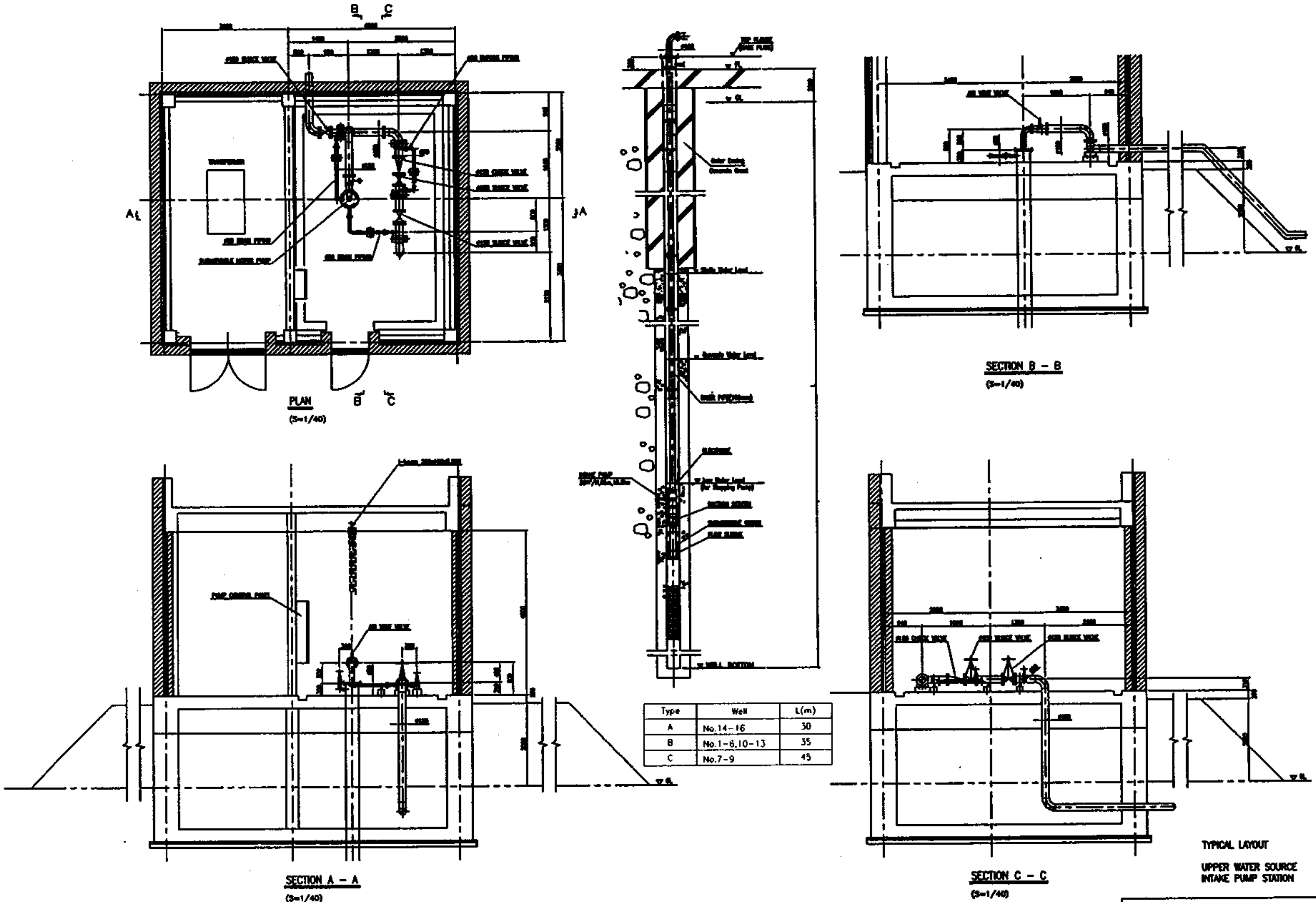
Upper Water Source Well Structure

図3－8　上流水源井戸構造図

Scale: NONE

Drawing No. 2-8




| Type | Well | L(m) |
|---|---|---|
| A | No.14-16 | 30 |
| B | No.1-6,10-13 | 35 |
| C | No.7-9 | 45 |

TYPICAL LAYOUT

UPPER WATER SOURCE
INTAKE PUMP STATION

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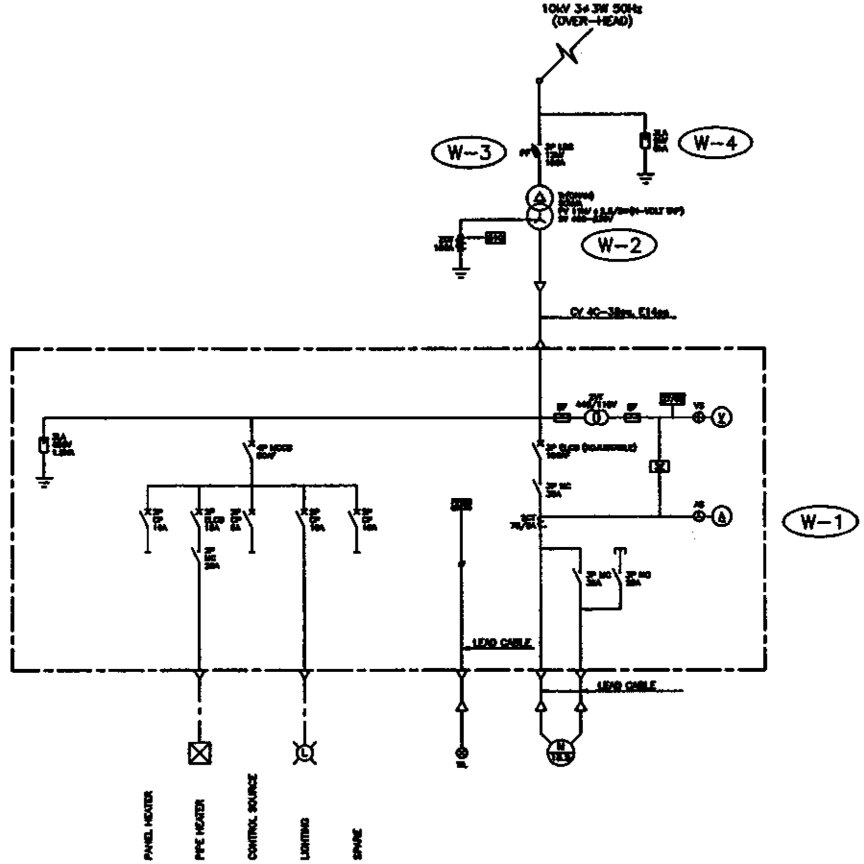
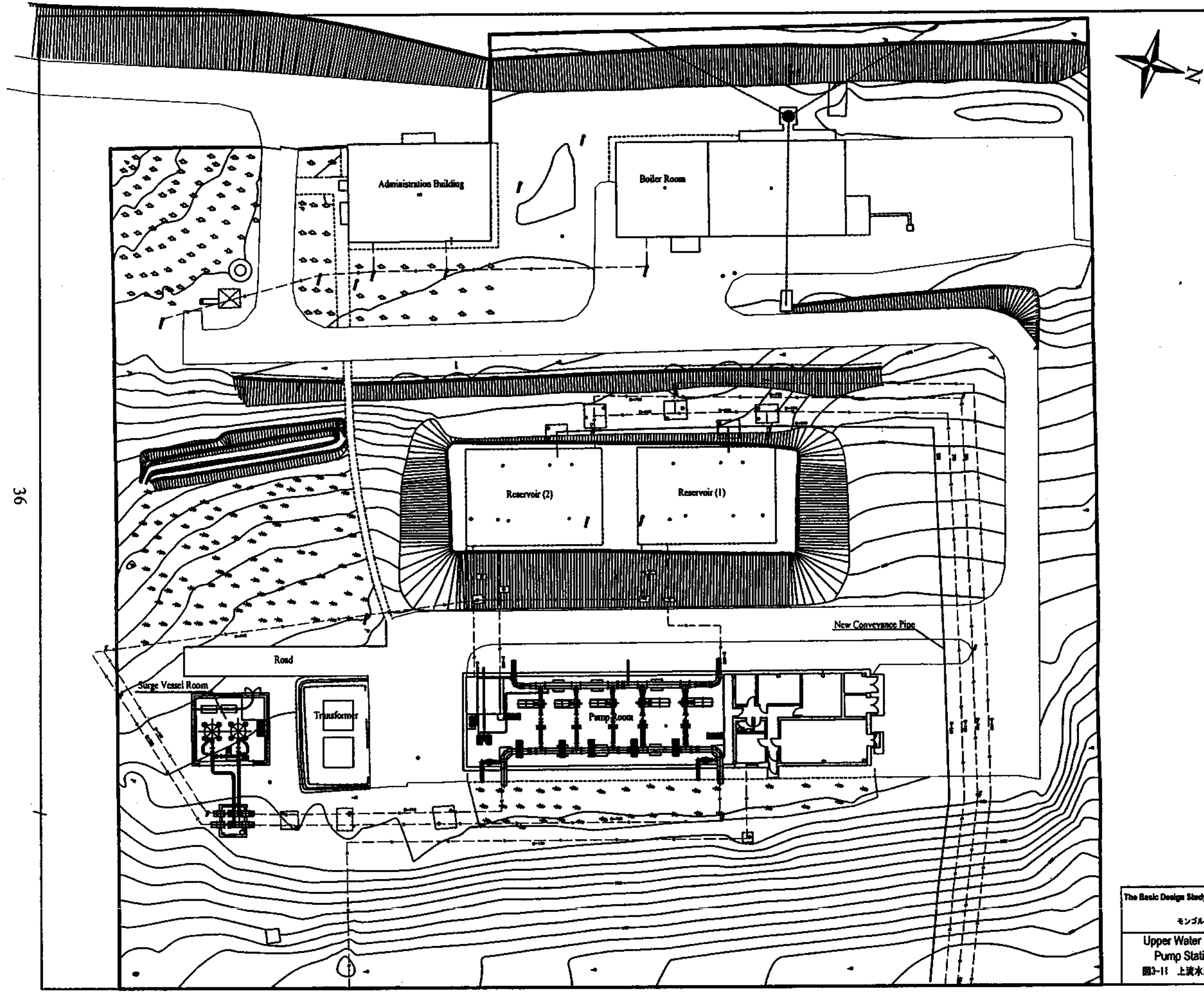
Upper Water Source Well Pump Station
Plan and Section
図３－９　上流水源井戸ポンプ場平断面図

Scale: 1/40
Drawing No. 2-9




| | | |
|---|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | | |
| Upper Water Source Well Pump Station<br>S.L.D.<br>図3-10　上流水源井戸ポンプ場単線結線図 | Scale: NONE | Drawing No. 2-10 |

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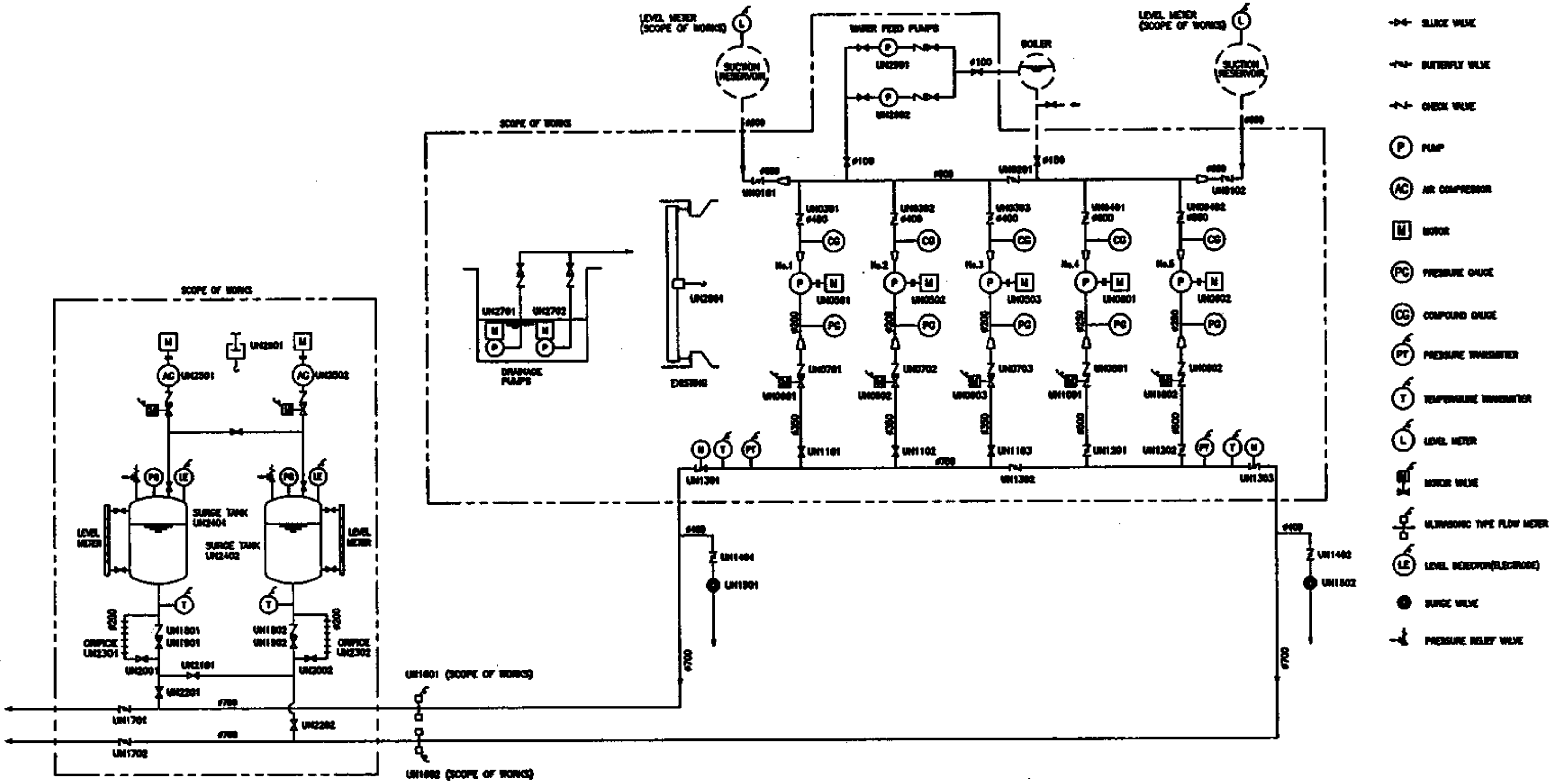
Upper Water Source Transmission Pump Station General Layout
図3-11 上流水源送水ポンプ場一般平面図

Scale: NONE
Drawing No. 2-11




| Equipment No. | UN0101/0102 | UN0201 | UN0301/0303 | UN0401/0402 | UN0501/0503 | UN0601/0602 | UN0701/0703 | UN0801/0802 | UN0901/0903 | UN1001/1002 | UN1101/1103 | UN1201/1202 | UN1302 | UN1401/1402 | UN1501/1502 | UN1601/1602 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equipment Name | Butterfly Valve | Butterfly Valve | Butterfly Valve | Butterfly Valve | Double Suction Pump | Double Suction Pump | Check Valve | Check Valve | Motor Operated Sluice Valve | Motor Operated Butterfly Valve | Sluice Valve | Butterfly Valve | Butterfly Valve | Butterfly Valve | Surge Valve | Flow Meter |
| Specification | Diameter:600 mm<br>JIS 10K | Diameter:600 mm<br>JIS 10K | Diameter:400 mm<br>JIS 10K | Diameter:600 mm<br>JIS 10K | Dia.: 300X200 mm<br>Capacity: 950m3/h<br>Head: 140 m | Dia.: 450X250 mm<br>Capacity:1900m3/h<br>Head. 140 m | Diameter: 350 mm<br>JIS 16K | Diameter: 500mm<br>JIS 16K | Diameter: 350 mm<br>JIS 16K | Diameter: 500 mm<br>JIS 16K | Diameter: 350 mm<br>JIS 16K | Diameter: 500 mm<br>JIS 16K | Diameter: 700 mm<br>JIS 16K | Diameter: 400 mm | Diameter: 400 mm | Diameter: 700 mm<br>Type: Ultrasonic |
| Motor kW | - | - | - | - | 630 | 1050 | - | - | 2.2 | 0.75 | - | - | - | - | - | - |
| Quantity | 2 | 1 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 1 |
| Remarks | | | | | | | | | | | | | | Existing | Existing | |

| Equipment No. | UN1701/1702 | UN1801/1802 | UN1901/1902 | UN2001/2002 | UN2101 | UN2201/2202 | UN2301/2302 | UN2401/2402 | UN2501/2502 | UN2601 | UN2701/2702 | UN2801 | UN2901/2902 | UN1301/1303 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Equipment Name | Butterfly Valve | Check Valve | Sluice Valve | Sluice Valve | Sluice Valve | Sluice Valve | Orifice Plates | Surge Tank | Compressor Unit | Chain Block | Drainage Pump<br>Submersible Pump | Overhead Crane | Water Feed Pump | Motor Operated Butterfly Valve (Flow Control) |
| Specification | Diameter: 700 mm<br>JIS 16K | Diameter: 300 mm<br>JIS 16K | Diameter: 300 mm<br>JIS 16K | Diameter: 200 mm<br>JIS 16K | Diameter: 300 mm<br>JIS 16K | Diameter: 300 mm<br>JIS 16K | Diameter: 200 mm<br>Stainless Steel | Capacity .20 m3 | Capa.:0.79m3/min<br>Pressure: 1.4 Mpa | Capacity:1 Ton | Capacity:0.5m3/min<br>Head: 10 m | Capacity : ton<br>Span m<br>Lift m | Capa.: 1.33m3/min<br>Head: 50 m | Diameter: 700 mm<br>JIS 16K |
| Motor kW | - | - | - | - | - | - | - | - | 11 | - | 2.2 | - | 11 | 1.5 |
| Quantity | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 |
| Remarks | | | | | | | | | | | | Existing | | |

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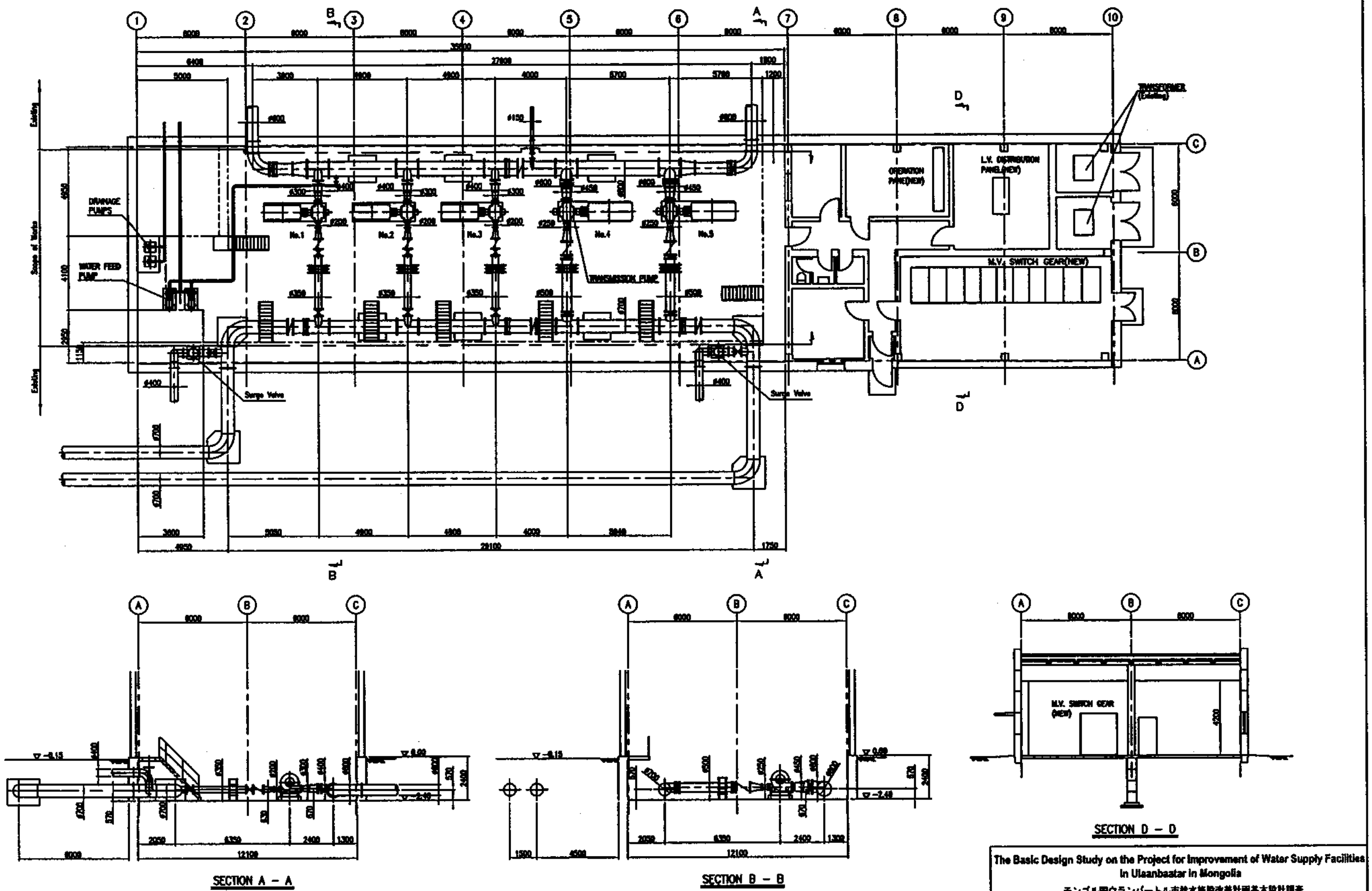
| | |
|---|---|
| Upper Water Source Transmission Pump Station<br>Flow Diagram<br>図3-12 上流水源送水ポンプ場フローダイアグラム | Scale: NONE<br>Drawing No. 2-12 |




The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia

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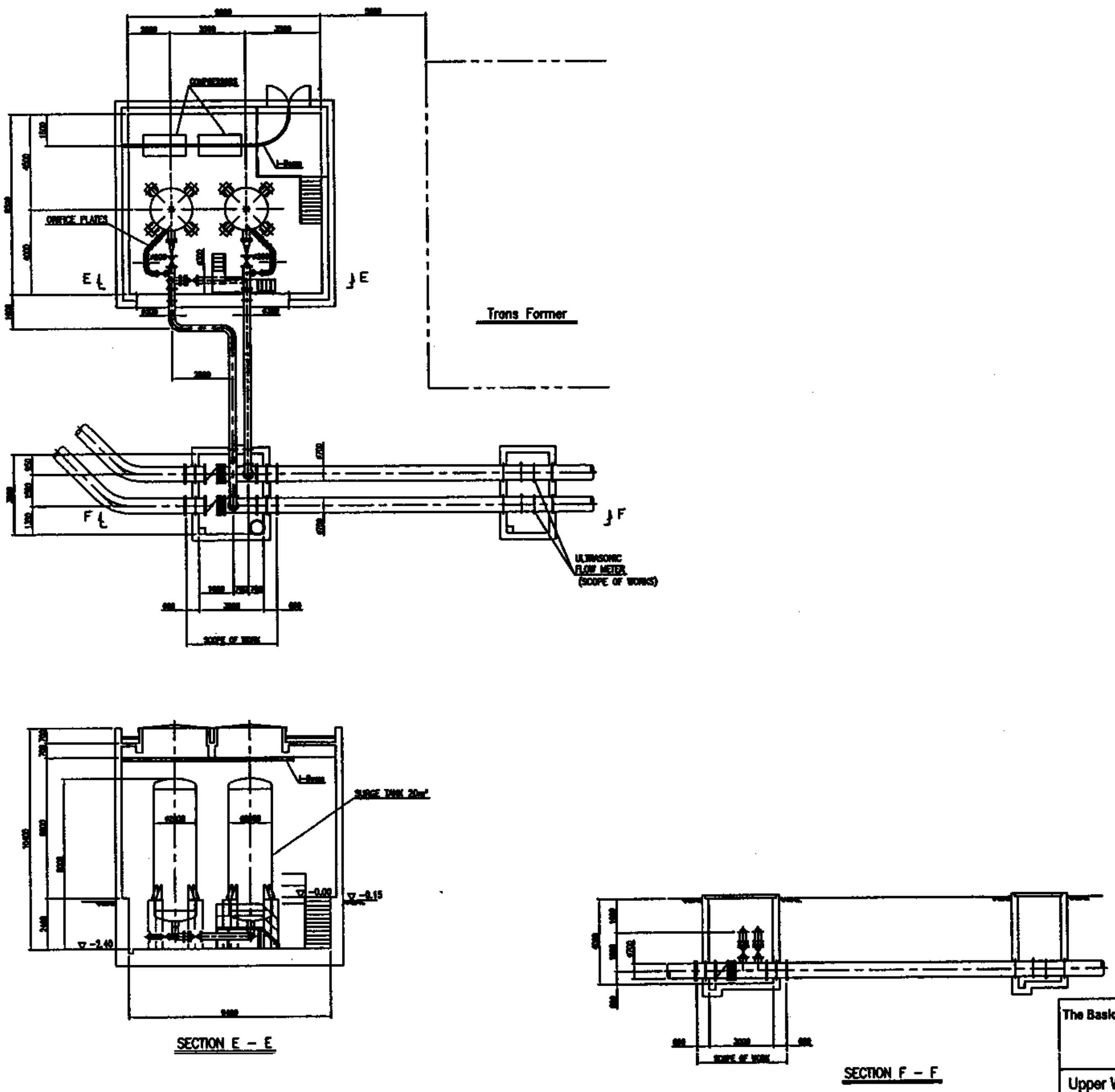
Upper Water Source Transmission Pump Station Plan and Section

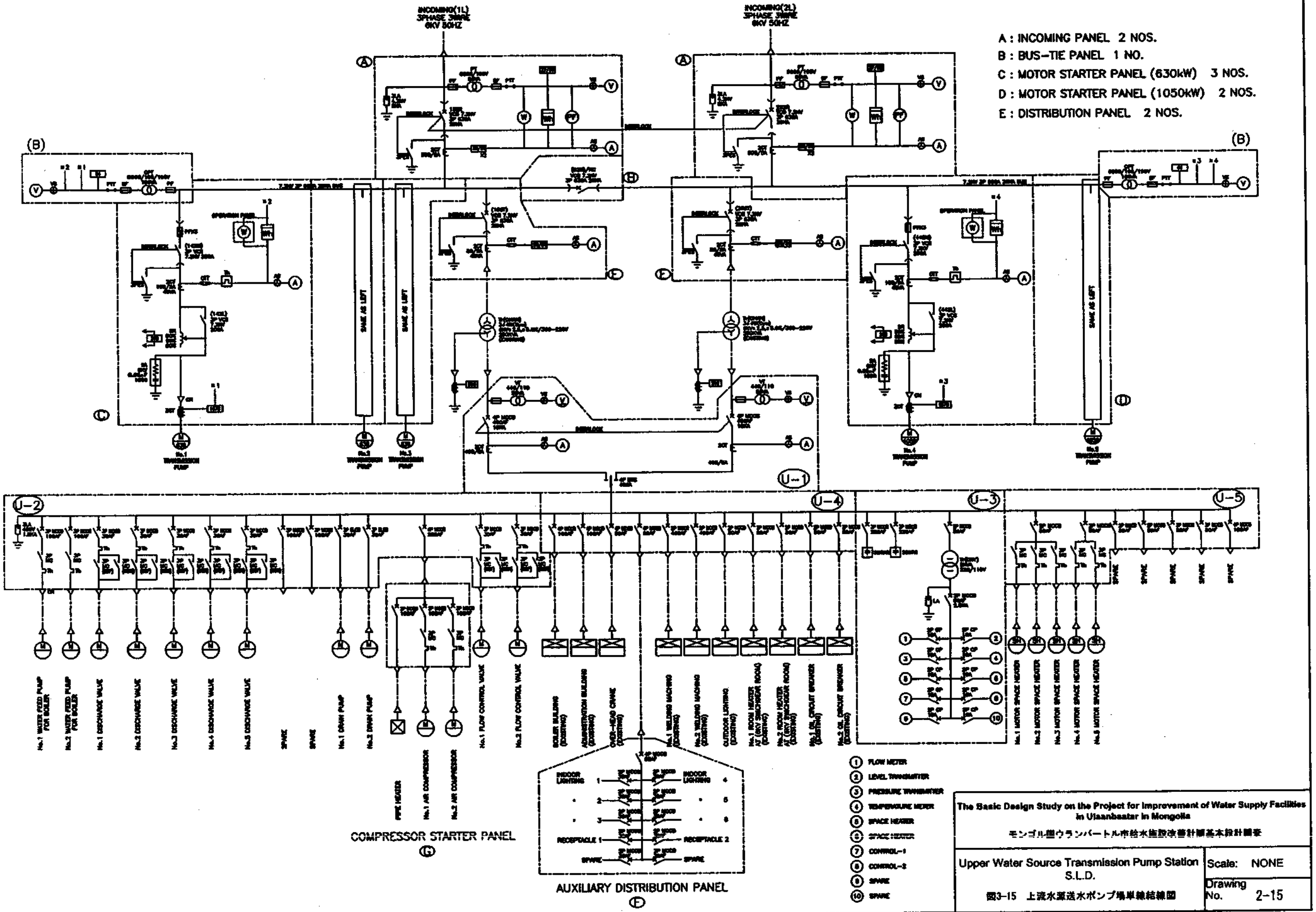
図3-13 上流水源送水ポンプ場平断面図

Scale: 1 / 200

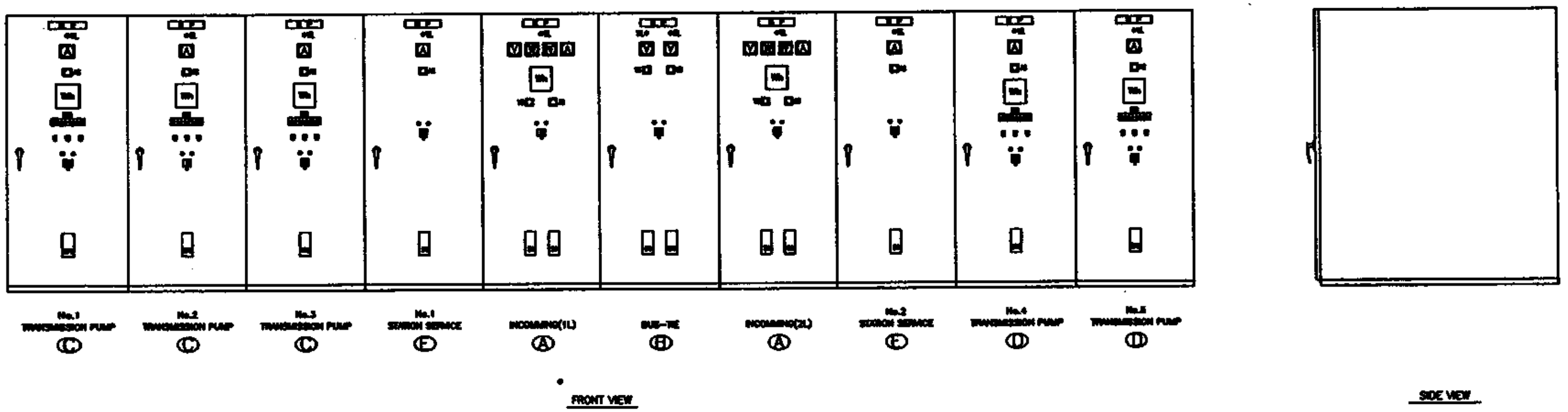
Drawing No. 2-13



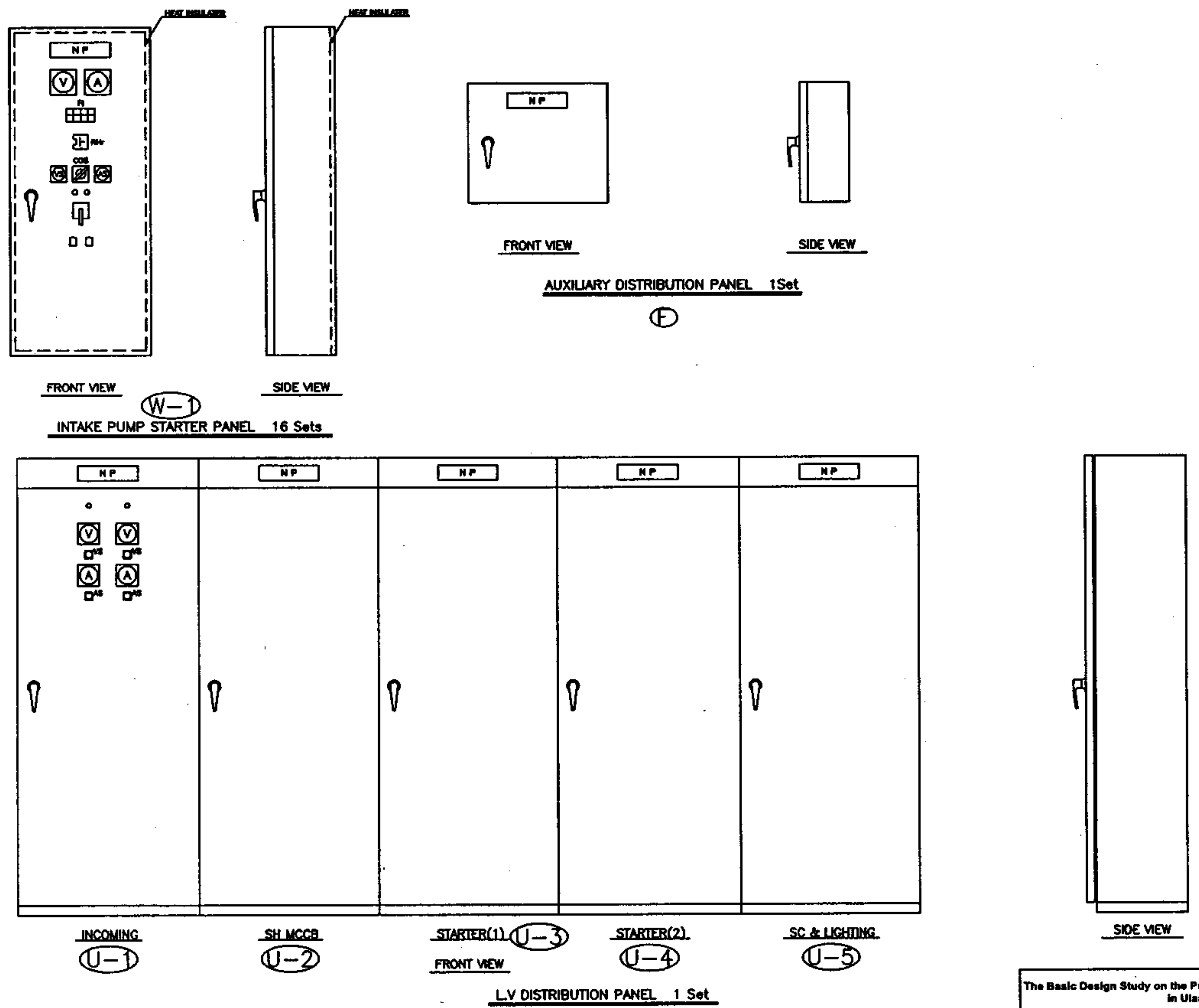

| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Upper Water Source Transmission Pump Station<br>Surge Vessel Structure<br>図3-14　上流水源送水ポンプ場サージベッセル室平断面図 | Scale: 1 / 200<br>Drawing No. 2-14 |



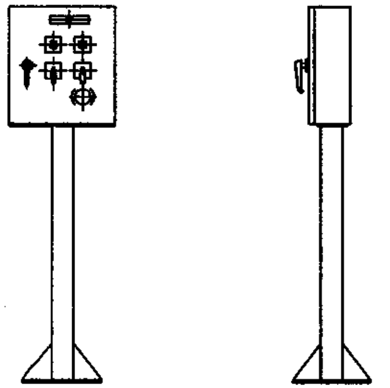

| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Upper Water Source Transmission Pump Station S.L.D.<br>図3-15 上流水源送水ポンプ場単線結線図 | Scale: NONE<br>Drawing No. 2-15 |




| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Upper Water Source Transmission Pump Station<br>MV Distribution Panel<br>図3-16 上流水源送水ポンプ場高圧配電盤 | Scale: NONE<br>Drawing No. 2-16 |



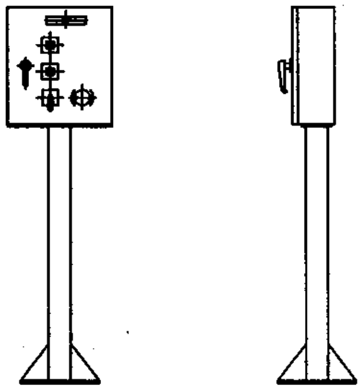

| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Upper Water Source Transmission Pump Station<br>LV Distribution Panel & Others<br>図3-17 上流水源送水ポンプ場低圧配電盤 他 | Scale: NONE<br>Drawing No. 2-17 |



FRONT VIEW SIDE VIEW

TRANSMISSION PUMP 5 Sets

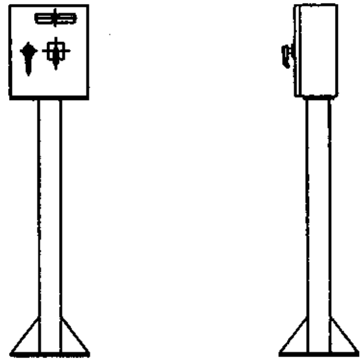
(H)



FRONT VIEW SIDE VIEW

WATER FEED PUMP 1 Set

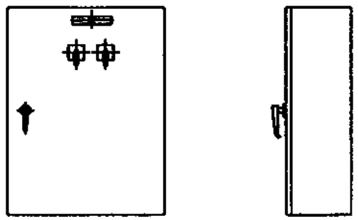
(I)



FRONT VIEW SIDE VIEW

VALVE CONTROL 2 Set

(J)

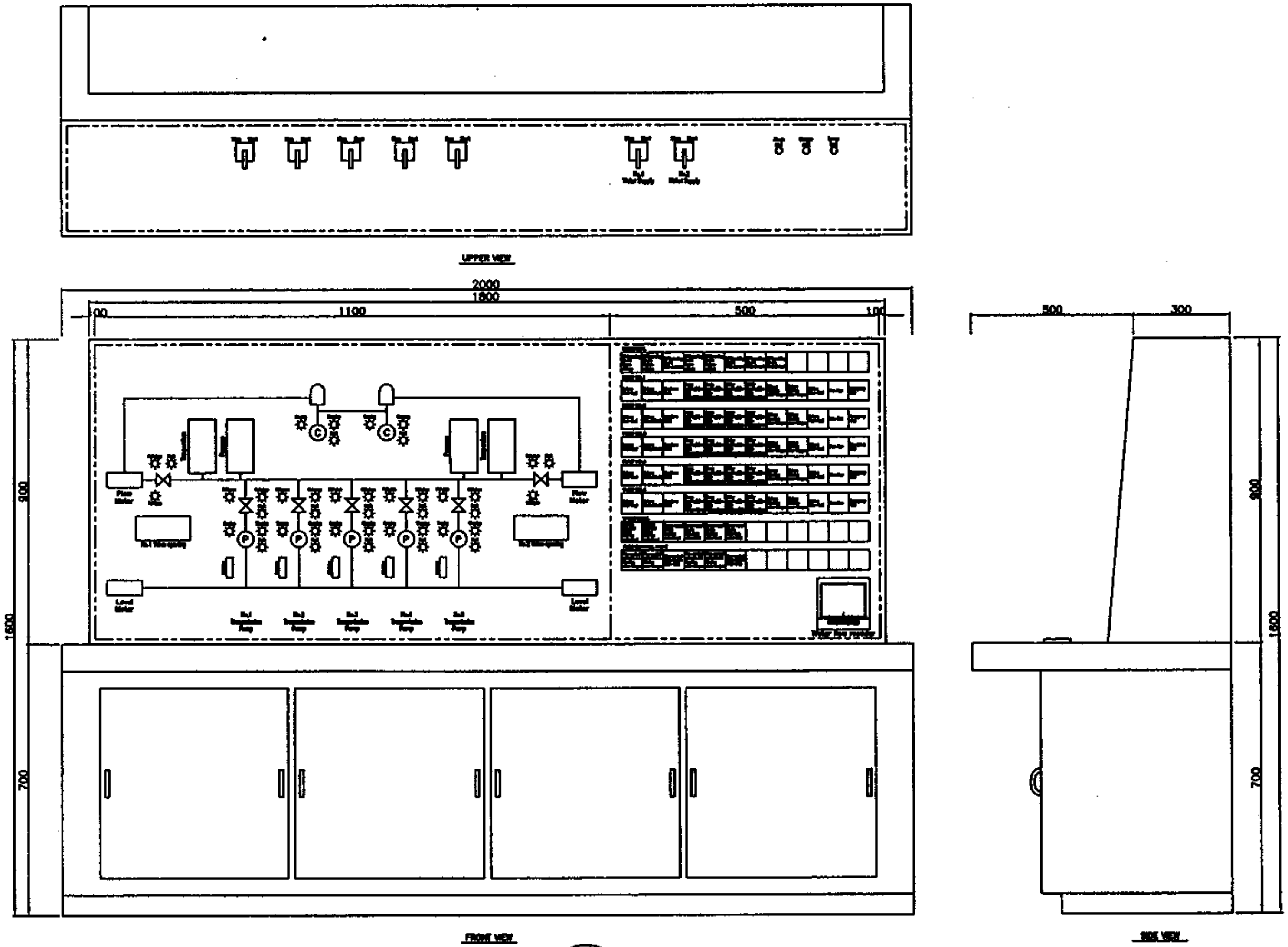


FRONT VIEW SIDE VIEW

AIR COMPRESSOR 1 Set

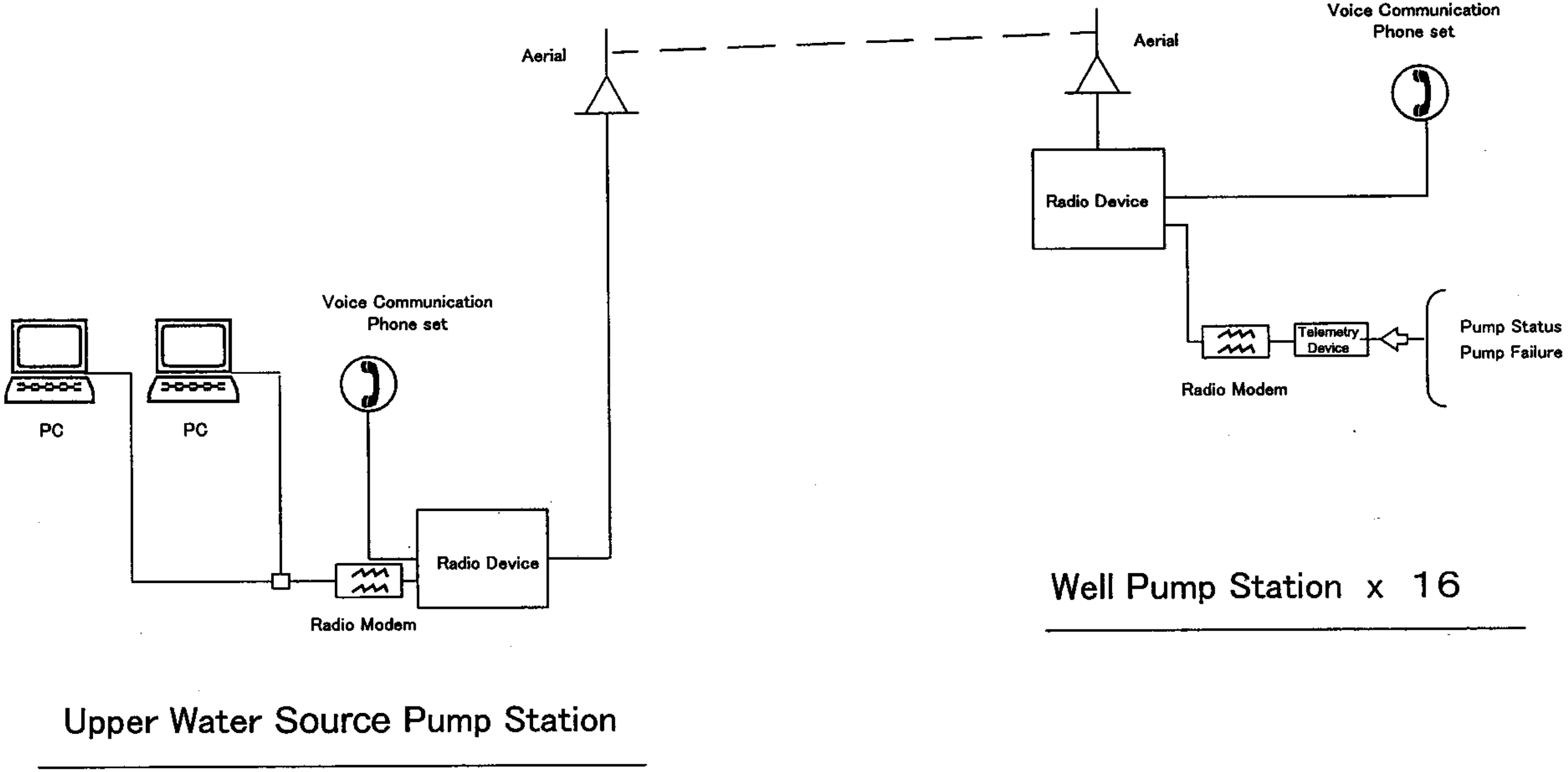
(G)

| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Upper Water Source Transmission Pump Station<br>Local Control Panel<br>図3-18 上流水源送水ポンプ場現場操作盤 | Scale: NONE<br>Drawing No. 2-18 |



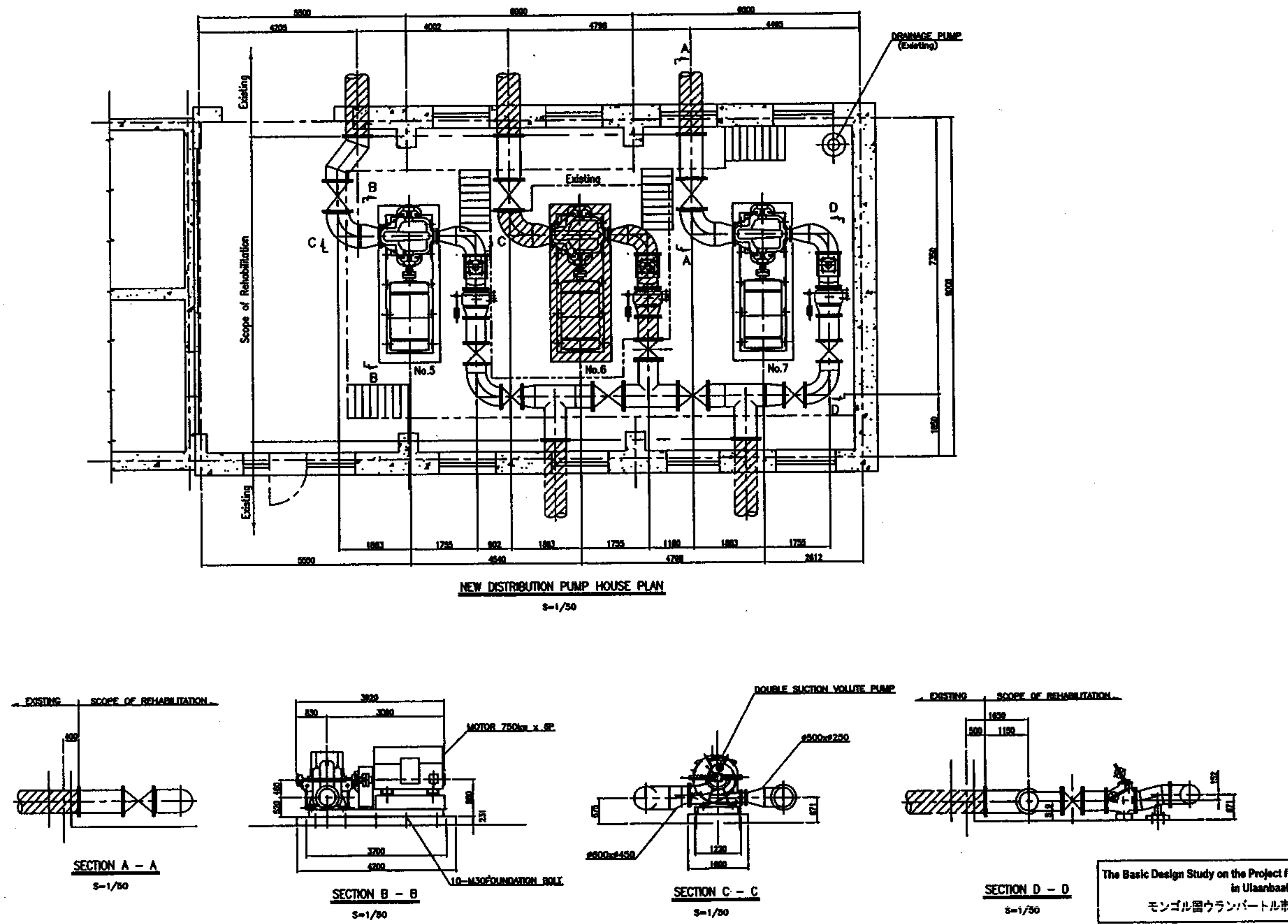

OP

| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Central Water Source Transmission Pump Station Operation Panel | Scale: 1 / 25 |
| 図3-19 上流水源送水ポンプ場運転操作監視盤 | Drawing No. 2-19 |

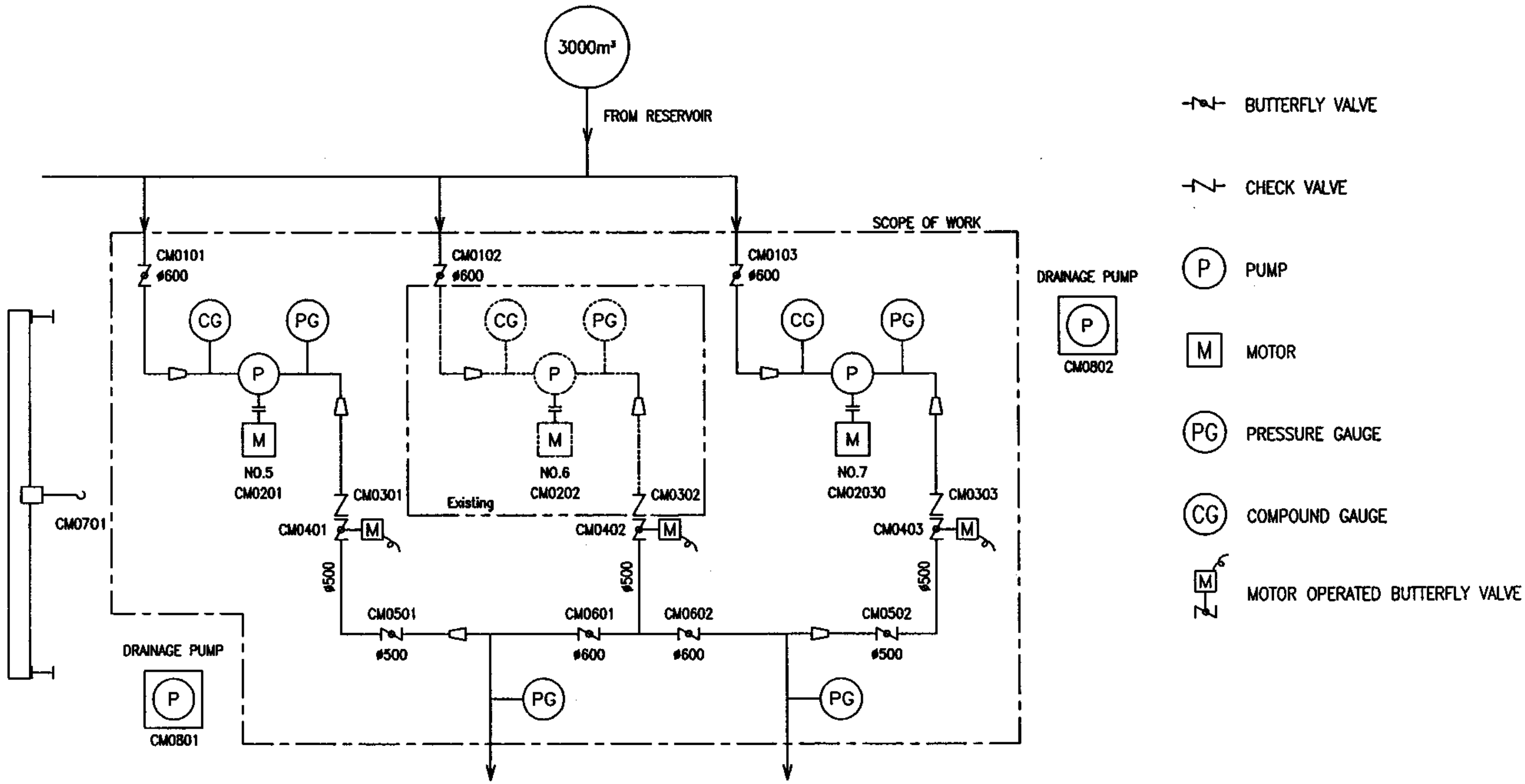



# Upper Water Source Remote Control System

| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Upper Water Source<br>Remote Control System Diagram<br>図3-20 上流水源遠隔操作システムダイアグラム | Scale: NONE<br>Drawing No. 3-20 |




| | | |
|---|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | | |
| Central Water Source Distribution Pump Station (New Facility) Plan & Section | Scale: | 1 / 100 |
| 図3-21 中央水源配水ポンプ場（新施設）平断面図 | Drawing No. | 2-21 |




| Equipment No. | CM0101/0103 | CM0201, 0203 | CM0301, 0303 | CM0401/0403 | CM0501/0502 | CM0601/0602 | CM0701 | CM0801/0802 |
|---|---|---|---|---|---|---|---|---|
| Equipment Name | Butterfly Valve | Double Suction Pump | Check Valve | Motor Operated Butterfly Valve | Butterfly Valve | Butterfly Valve | Overhead Crane | Drainage Pump |
| Specification | Diameter: 600 mm | Diameter: 600 mm<br>Capacity:2000m3/h<br>Head: 100 m | Diameter: 500 mm | Diameter: 500 mm | Diameter: 500 mm | Diameter: 600 mm | Capacity : ton<br>Span: m<br>Lift : m | Diameter: mm |
| Motor kW | - | 750 | - | 0.75 | - | - | - | - |
| Quantity | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 2 |
| Remarks | | CM0202: Existing | CM0302: Existing | | | | Existing | Existing |

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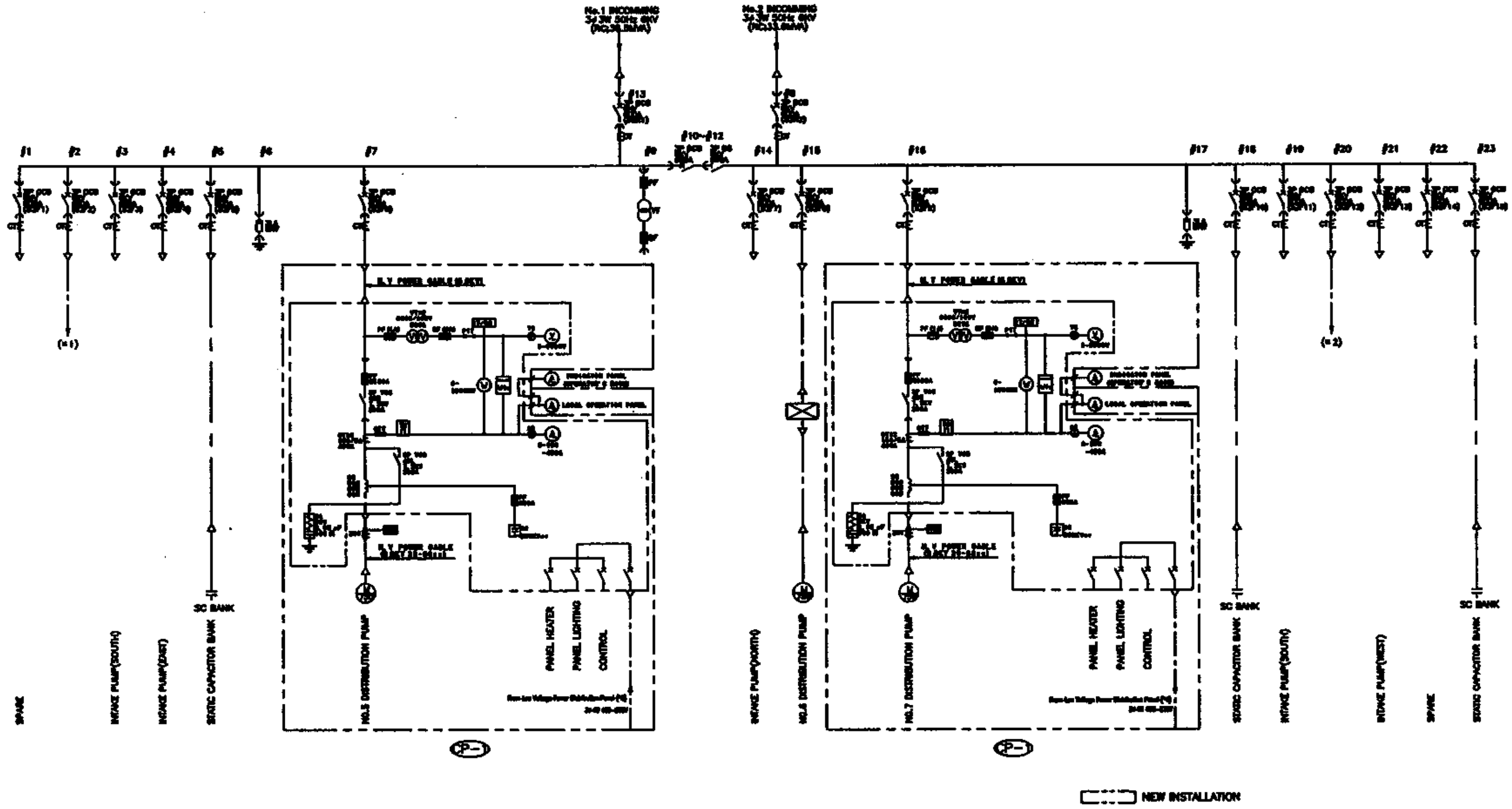
Central Water Source Distribution Pump Station (New Facility) Flow Diagram
図3-22 中央水源配水ポンプ場（新施設）フローダイアグラム

Scale: NONE
Drawing No. 2-22

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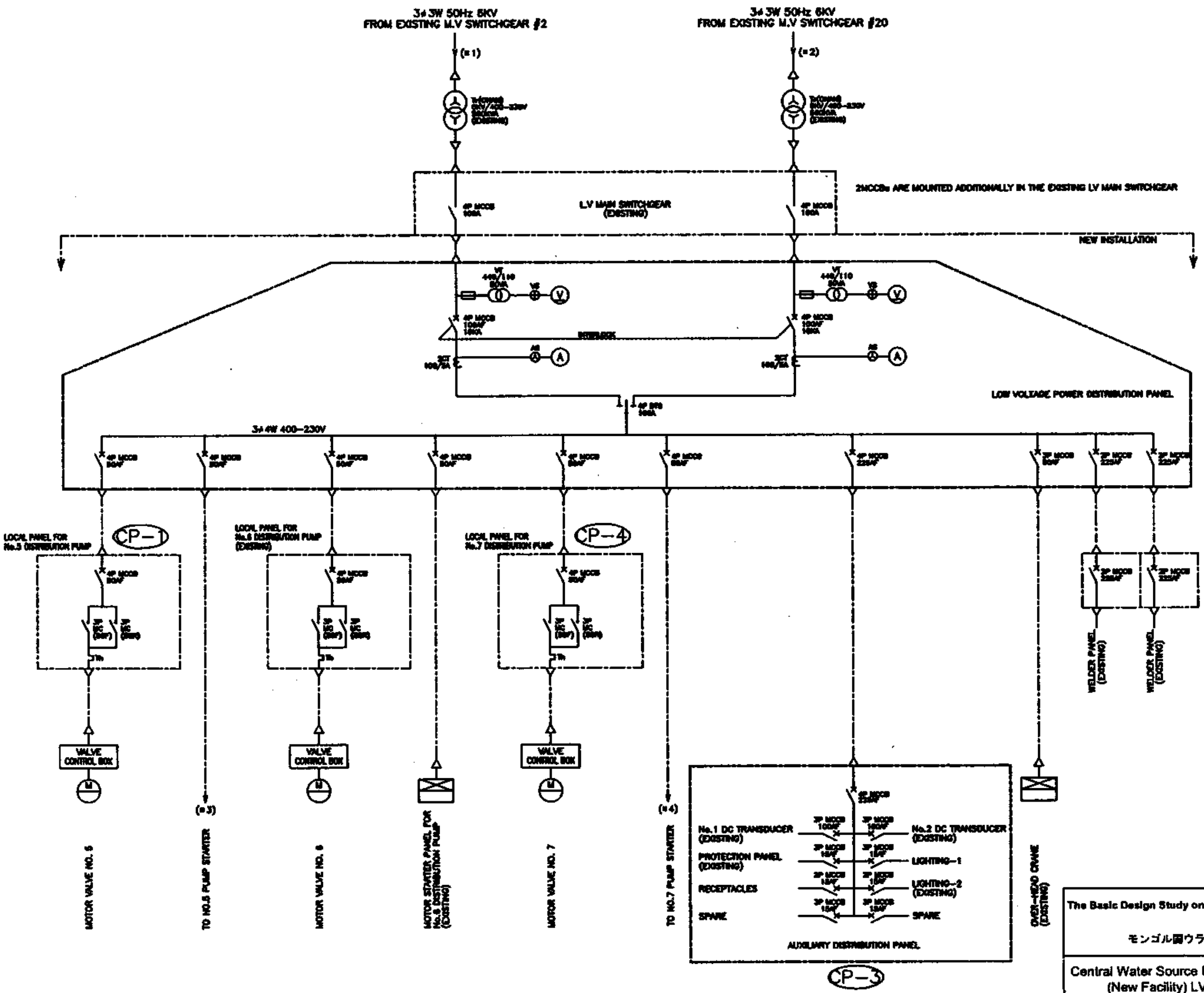
| | | |
|---|---|---|
| Central Water Source Distribution Pump Station (New Facility) MV Distribution S.L.D. | Scale: | NONE |
| 図3-23 中央水源配水ポンプ場（新施設）単線結線図（高圧） | Drawing No. | 2-23 |




The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia

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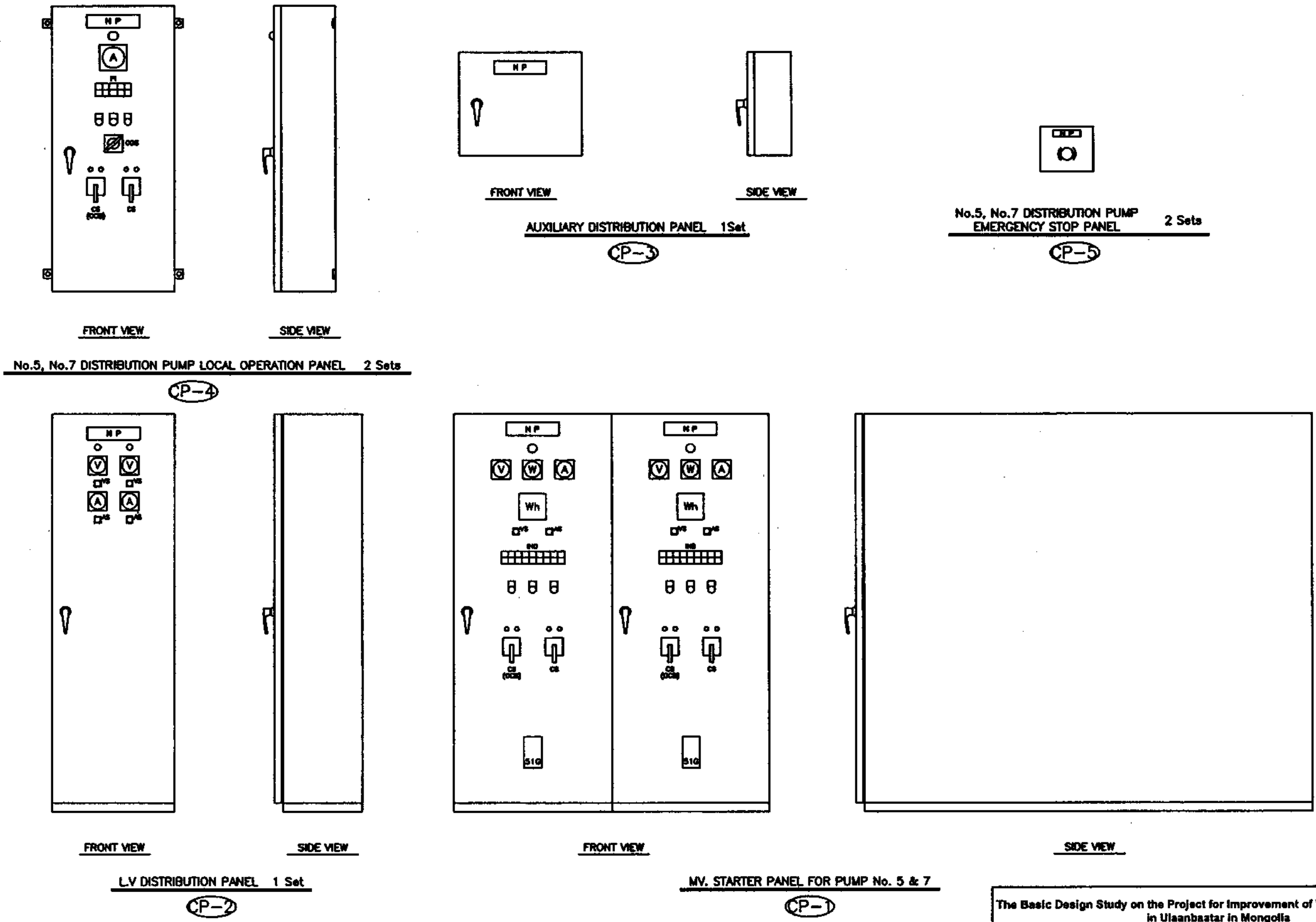
| | |
|---|---|
| Central Water Source Distribution Pump Station (New Facility) LV Distribution S.L.D.<br>図3-24 中央水源配水ポンプ場（新施設）単線結線図（低圧） | Scale: NONE<br>Drawing No. 2-24 |




| | |
|---|---|
| The Basic Design Study on the Project for Improvement of Water Supply Facilities in Ulaanbaatar in Mongolia<br>モンゴル国ウランバートル市給水施設改善計画基本設計調査 | |
| Central Water Source Distribution Pump Station (New Facility) Distribution and Local Operation Panel<br>図3-25 中央水源配水ポンプ場（新施設）配電盤・操作盤 | Scale: NONE<br>Drawing No. 2-25 |

### 2-2-4 Implementation Plan

#### 2-2-4-1 Implementation Policy

The implementing organization of this project for Mongolia is USAG under Ulaanbaatar City supervision. The organization chart is shown below:

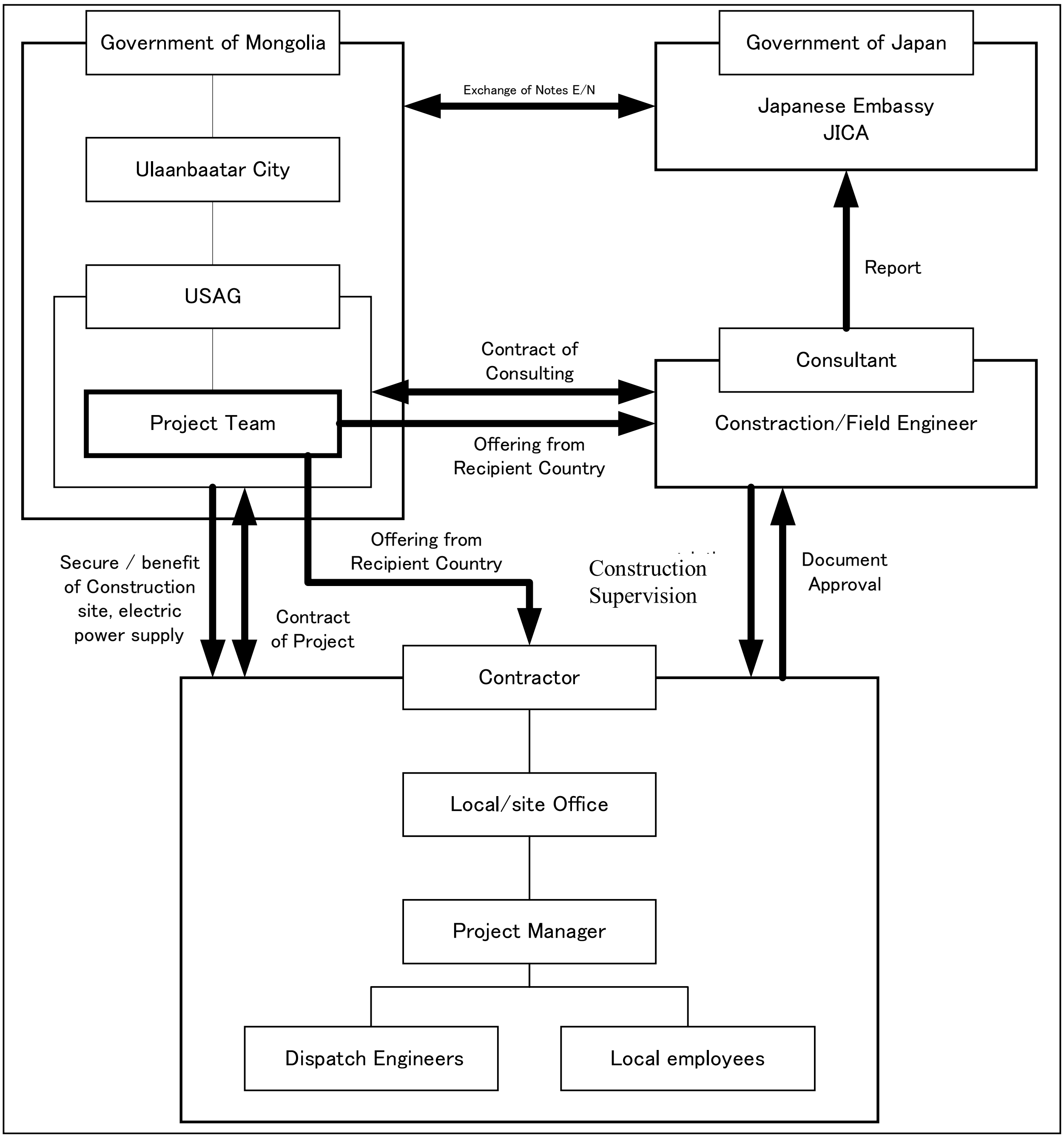



Figure 2-26 Project Implementation Organization

The project team is established in USAG to take charge of the entire project from the detailed design stage until completion. The role of the project team established the inside the same office is the following.

a. Window of USAG to this project
b. Administration of communication/coordination with related departments of the Ulaanbaatar City and the Government of Mongolia
c. Administration of communication/coordination with the outside organizations with regard to the project
d. Arrangement of the tender documents as the counterpart of consultant
e. Arrangement of staff for additional survey and tests if needed

Japanese consultants will accomplish the following tasks: detailed design, preparing tender document, and construction supervision within a specified period.

On behalf of USAG, a construction project manager from the consultants will be stationed at the construction site according to construction schedule to dispatch and manage the project by sending the particular field consultants, depending on the progress of construction, such as the well engineer, civil engineer, mechanical engineer, electricity etc.

The general contractor that is selected for the project should have significant experience in well construction and laying pipeline, and similar construction work. For selection of the contractor, a general open bidding process shall be used. The bidding procedures and documents such as for tender participation and qualification, evaluation and selection standards will be agreed between USAG and the consultants.

During construction period, the engineer from the Japanese contractor is stationed at the project site and will supervise the work. The construction industry in Mongolia is progressing and the local engineering and construction companies may be used as subcontractors.

#### 2-2-4-2 Implementation Conditions

The work is composed of the construction of the wells and pump buildings, laying raw water transmission main, and rehabilitation of mechanical and electrical equipment for transmission pump stations. The locations of the site office, contractor lay-down area, etc. will be decided in consultation with USAG. The use of local workers, materials and construction equipment in the execution of this project is encouraged. Local contractors will be used as a sub-contractors.

Considerations on construction are as follow:

1) From November to March, the average temperature is below 0°Celsius and the minimum temperature is below－10°Celsius. Outside construction work during this five month period of the year is not possible.
2) Yearly average precipitation is about 300 mm, a daily rainfall over 10 mm may occur, which will result in a decrease in the efficiency of execution.
3) The construction methods that are used should for the wells, pipelines and other facilities should be selected with consideration to preserve the environment because the site is adjoining the Terelj Natural

protection area. The selection of construction methods will require scrupulous discussions with environment department.

4) The proposed well development site is a riverside area with many boulders and stones. The selection of the well drilling method should consider the above site condition. Also the well drilling period is limited to certain times during the year. The contractor should consider this in the acquisition and arrangement for drilling equipment.
5) The proposed well development site is about 40 km from the central Ulaanbaatar City. The contractor shall consider the need to transport construction material and equipment, as well as arrangement of the laborers and workers.
6) Protection of the raw water transmission main line, well pumps, vessel building etc. is required to prevent freezing during the construction and service periods. Measures to prevent such freezing should be considered during the design stage. Also, measures to execute the concrete work even during low temperature periods should be developed during the design stage.
7) During execution of rehabilitation of transmission pumps, the interruption of service shall be minimized.
8) Dewatering should be considered for construction of raw water transmission pipeline, because ground water level is high and the permeability is extremely high.
9) Adequate quality control of concrete mixing should be provided.
10) Well construction work, pump installation work, test run, welding inspection etc., shall be carried out under supervision of an engineer dispatched from Japan.
11) With regard to VAT, etc., the normal policies and procedures apply.

### 2-2-4-3 Scope of Works

The scope of works agreed in the minutes of meeting between Mongolia side and Japan side is shown as following:

Table 2-21 Scope of Works for Execution of Works

| Item | Content | Mongolia side | Japan side |
|---|---|---|---|
| Offering lagging materials for existing 39 wells and new 16wells | Procurement and delivery to USAG | | X |
| | Installation | X | |
| Construction of wells and raw water transmission pipe line | Procurement of construction materials | | X |
| | Execution of construction works | | X |
| | Installation | | X |
| | Acquisition of land | X | |
| | Installation of a fence | X | |
| | Provide of a power-transmission wire for new line | X | |
| | Acquisition of EIA approval etc | X | |
| Rehabilitation of transmission pumps | Dismantle and dispose of existing pumps | X | |
| | Procurement | | X |
| | Installation, adjustment and test run | | X |

Table 2-22 Main Agreed Scope of Work between Two Governments

| No. | Items | | | JICA side (Grant Aid) | Mongolia side (Local portion) |
|---|---|---|---|---|---|
| 1 | To secure land | | | | ● |
| 2 | To clear, level and reclaim the site | | | | ● |
| 3 | To construct gates and fences in and around the site | | | | ● |
| 4 | To construct the parking lot | | | ● | |
| 5 | To construct roads | | | | |
| | 1) | Within the site | | ● | |
| | 2) | Outside the site | | | ● |
| 6 | To construct the building | | | ● | |
| 7 | To provide facilities for the distribution of electricity, water supply, drainage and other incidental facilities | | | | |
| | 1) | Electricity | | | |
| | | a. | The distributing line to the site | | ● |
| | | b. | The drop wiring and internal wiring within the site | ● | |
| | | c. | The main circuit breaker and transformer | ● | |
| | 2) | Water Supply | | | |
| | | a. | The water pipe line from the city water distribution main to the site | | ● |
| | | b. | The supply system within the site (receiving and elevated tanks) | ● | |
| | 3) | Drainage | | | |
| | | a. | The drainage to the city drainage main (for storm sewer and others to the site) | | ● |
| | | b. | The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site | ● | |
| | 4) | Gas Supply | | | |
| | | a. | The gas line from the city gas main to the site | | ● |
| | | b. | The gas supply system within the site | ● | |
| | 5) | Telephone System | | | |
| | | a. | The telephone trunk line to the main distribution frame/panel (MDF) for the building | | ● |
| | | b. | The MDF and the extension after the frame/panel | ● | |
| | 6) | Furniture and Equipment | | | |
| | | a. | General furniture | | ● |
| | | b. | Project equipment | ● | |
| 8 | To bear the following commissions to the Japanese bank for banking service based upon the B/A | | | | |
| | 1) | Advising commission of A/P | | | ● |
| | 2) | Payment commission | | | ● |
| 9 | To ensure unloading and customs clearance at port of disembarkation in recipient country | | | | |
| | 1) | Marine (Air) transportation of the products from Japan to the recipient | | ● | |
| | 2) | Tax exemption and custom clearance of the products at the port of disembarkation | | | ● |
| | 3) | Internal transportation from the port of disembarkation to the project site | | (●) | (●) |
| 10 | To accord Japanese nationals, whose service may be required in connection with the supply of the products and the services under the verified contract, such facilities as may be necessary for their entry into the recipient country and stay therein for the performance of their work | | | | ● |
| 11 | To exempt Japanese nationals from customs duties, internal taxes and other fiscal levies which may be imposed in the recipient country with respect to the supply of the products and services under the verified contacts | | | | ● |
| 12 | To maintain and use properly and effectively the facilities contracted and equipment provided under the Grant | | | | ● |
| 13 | To bear all the expenses, other than those to be borne by the Grant, necessary for construction of the facilities as well as for the transportation and installation of the equipment | | | | ● |

Remarks B/A: Banking Arrangement, A/P: Authorization to Pay

### 2-2-4-4 Consultant Supervision

After this basic design study is completed, this project will be approved by a cabinet meeting of Japanese government. And “Exchange of Note (E/N) the signature regarding the gratuitous funds cooperation to the project" will be signed between two governments.

#### 1) Detail Design

When Japanese government decides in favor of the use of Grant Aid fund cooperation based on the basic design study, the signature of Exchange of Note is done between Mongolia government and Japanese government. The consultant will carry out a detailed design after the contract is signed with the Mongolian government and verification are obtained from the Japanese government. The consultants will carry out the field survey including location measurement survey at the start of the detailed design. The detailed design, tender documents, and construction budget will be prepared by the consultant in Japan.

#### 2) Tendering

Following approval of the tender documents by USAG, the tender will be executed. The tendering process will be as follows:

a. Consultants accept the tender participation application one week after the bid announcement.
b. Consultants evaluate the tender participation qualifications after the acceptance of the tender participation application.
c. Tender documents will be distributed to qualified contractors. The contractors will have 1.5 months to prepare their bids.
d. Consultants will recommend to USAG which contractor is the lowest bid price for this project and support the promotion of the official announcements.

#### 3) Execution Management

The construction work includes a variety of elements, including well drilling and construction, pipe laying work, and mechanical, electrical and civil work. The consultant will dispatch a civil engineer who will serve as the station manager. The other engineers that will be dispatched from Japan include civil, mechanical, structural and electrical engineers. Each field engineer shall be dispatched several times, according to the progress of the main construction work of each discipline.

The consultant will employ a local location engineer to assist the consultant’s station manager. Frequent progress meetings will be held with the station manager and the execution person from USAG during the execution of the project. The consultant will submit regular reports to the local JICA office and to JICA headquarters.

#### 2-2-4-5 Procurement Plan

### 1) Procurement Country

Materials and equipment shall be procured locally when possible. However, materials and equipment that cannot be obtained locally or in cases in which the locally available materials and equipment do not meet quality specifications may be procured from Japan or a country neighboring Mongolia, Russia, China and Korea which qualify as neighboring countries or OECD member nation.

The lead-time for delivery of Russian equipment is two months if the item is in stock, and six months if the item is not in stock. This project requires a short delivery time, because of the construction schedule. The relatively long delivery time is also a concern with regard to maintenance. Therefore, it is not considered advisable to procure equipment from Russia.

USAG has limited experience in Chinese products, and although Chinese products are less expensive there as concerns about the poor quality of products. The Client has observed a lack of quality control in the welding of pipes and measuring instruments.

#### a. Construction material

The quality of cement, reinforcing rods, aggregate and bricks in Mongolia is adequate for this project. Procurement of these materials within Mongolia is acceptable.

#### b. Piping Material

The steel pipe will be imported from either Japan or a 3rd country. However, the pipe that is procured for this project must meet strict specifications including those related to internal and external coating.

#### c. Material Related Well Construction

Although casing and screen materials and submersible pumps manufactured in the former Soviet Union have been used in the past, there is a problem with respect to the long delivery time term mentioned above. Therefore, Russian equipment is not acceptable for this project.

USAG has indicated that Chinese products are not accepted in the local market, because of poor quality, inadequate after sales service and unreliable performance. On the other hand, the Japanese products introduced in the last JICA project have demonstrated good reliability, performance, quality, durability etc. The reliability of the equipment that is selected is the critical factor for the success of this project. Therefore, the well construction materials shall be imported from Japan.

#### d. Material Related Transmission Pump Station

USAG owns pumps manufactured in Denmark and China. The Chinese pumps have operational problems and low efficiency. In terms of reliability, maintenance, energy efficiency the Japanese pumps procured in the last JICA project have performed exceptionally well. The transmission water pump is an important part of the Ulaanbaatar City water supply system, and the pumps shall be imported from Japan. Equipment for radio remote control system between new wells of 16 units and transmission pump station shall be imported from an OECD member nation.

#### e. Piping Insulation Material

Regarding the piping insulation materials, although products that meet the specifications are manufactured in both Japan and Western countries, Japanese manufactured material is preferred because there is a relatively short acquisition time.

Table 2-23 Classification of Procurement

| Item | Content | Procurement country | | |
|---|---|---|---|---|
| | | Mongolia | Japan | OECD member |
| Construction Material | Cement, aggregate, material/brick, reinforcing rod etc. | X | | |
| Piping Material | Steel pipe | | X | |
| Material related well construction | Casings<br>Screens For Deep well<br>Submerged pumps pump<br>Electricity material | | X<br>X<br>X<br>X | |
| Material related transmission pump station | Pumps 950 cu.m /hr<br>1900 cu.m /hr<br>Valves<br>Electricity material<br>Remote control system | | X<br>X<br>X<br>X | <br><br><br><br>X |
| Offering material | Lagging material<br>Covering material | X | X | |

### 2) Delivery and Storage Yard

The storage yard for material and equipment will be at the transmission pump station in the Upper Water Source Area.

### 2-2-4-6 Plan on Soft Component

The following soft components are deemed to be necessary for improving the project effectiveness.

- business structure strengthening
- efficiency increase of water supply facilities operation and management
- leakage detection
- environmental water quality monitoring
- public relations improvement

### (1) Background

#### 1) Business structure strengthening

USAG has been operating in deficit since 2000. To eliminate this deficit, World Bank recommends that USAG raise the rate for water. USAG is applying for a rate increase, but only a small increase was permitted. The small rate increase was the result of concerns about capacity of low-income consumers to pay a higher rate.

USAG does not have the capability to developing an adequate rate structure and to persuade the rate regulators that the rate is reasonable and necessary. To establish the rates for various customers it is necessary to consider the capital outlays, operation and maintenance costs, depreciation particularly in the transaction of facilities which are constructed by the grant aid, the obligation fees of water resources development (city or USAG), the costs for accounts receivable, the cost augmentation for arrangement of ger area, and the cost of servicing debt and repayment of the loans.

In the consideration of above-mentioned factors, and of the possibility of subsidy and varying service/facility level, it is possible to set a proper rate structure by calculation of the various costs. It is also important to be able to explain the justification for the rate structure. Also, as for the share of the cost of the facility construction behind the source of water investigation where the Ministry of International Trade and Industry mineral resource bureau goes at present, it is necessary to present an opinion promptly as USAG.

Therefore, it is effective to make the rate structure's simulation model and to study the various cases. And the rate structure's simulation model makes them understand the meaning of each item and consider the adequate management.

### 2) Efficiency increase of water supply facilities operation and management

The plan to supply water to the City by pumping through the Zavsariin reservoir from the Upper Water Source was developed to provide flow balancing to meet varying water demand. However, when water flowed through the facility, the valve located at the inlet to the reservoir did not operate properly. Even if water level reached the high water level, the pumps did not stop operating and water poured from the overflow pipe. Consequently, the road nearby was covered with water.

This was caused not only by a valve malfunction, but also because there was no means to transmit a signal to the Upper Water Source pump station, located approximately 30 km away, that the reservoir was full, and to stop the pumps. At present, water is supplied directly to the city not via the Zavsaariin reservoir. Because of high water pressure from the upper water transmission pump station, it is difficult to transmit much water. As the result, only 30 percent of planned volume is supplied to the City. World Bank project (scheduled completion in December 2003) will include improvements in the inflow valve and high level signal that will be sent to the Upper Water Source pump station by radio.

The 55 wells and the Upper Water Source transmission pumps will require careful operation given the relatively small storage capacity of only 6,000 cu. m, compared to a daily maximum transmission capacity of 90,000 cu. m/day. An operation guide is necessary to develop the most suitable pump operation mode to meet the varying demand.

There are several sources of water for Ulaanbaatar City, undercurrent water on the Tuul River, the Upper Water Source, the central water source, the industrial water source and the meat complex water source.

These conditions of the water sources are as follows:

- intake and transmission cost is different depend on the source of water
- fluorine is included above the acceptable level at the some wells in the industry water source
- resource of the meat complex, nitrate nitrogen is included in all well at the meat complex source (groundwater pollution is progressing).

At present, these sources are operated independently, based on the transmission system pressure. Therefore, the guide for water source selection should consider the cost and water quality available in selection of the appropriate mixture of water sources. The water sources should be selected to minimize cost, while ensuring acceptable water quality. The guide should also consider the potential for equipment failure, which will necessitate an alternate operating mode.

### 3) Leakage detection

USAG has a leakage investigation team as a division in its construction organization. The investigations are performed in areas where the ground is flooded, or where pressure declines. The investigations are not performed in a planned, systematic manner. The leakage detection equipment includes sound devices, correlational leak detectors, pipe and cable locators, etc. The leak detection team uses the equipment. However, there is a lack of basic knowledge of the relationship between the water pressure and the leakage, etc.

Because the pipe depth ranges from 2.5 m to about 5 m, it is difficult to detect leaks from the road surface so this method is rarely used. Correlational leak detectors are mainly used. However, if the location of leakage is found out, sometimes there is a case that this point is not the actual point of leakage.

This is due to the following reasons.

- there are manholes and isolation valves in the branch part to CTP, but in some cases the interval is too long and there are some places that management does not want to be investigated
- the information in the pipe route maps is insufficient

To improve detection of leakage and subsequent repairs, it is necessary for the staff to obtain a better understanding of leakage, the application of investigation methods, and arrangement of pipe route figures/survey results.

### 4) Environmental water quality monitoring

All the source of water in Ulaanbaatar City is groundwater. However, because it is a geological feature with very high water permeability, when surface water is polluted, the groundwater is polluted by infiltration.

There is a sewerage system that serves the apartments and factories. This system discharges downstream of the source water areas. However, the ger area, which is rapidly expanding into the areas surrounding the

City, is not served by a sewerage system. It is expected that the population of Ulaanbaatar City will reach 1,000,000 in 2010, and that 50% of the population will be living in the Ger areas. The present water consumption in the ger area is low (an average of 6 L/capita/day), but it is estimated to increase by 25 L/capita/day when water supply to this area is improved by the aid of World Bank. Currently, there are no programs to reduce the pollutant load from the Ger areas.

The new Upper Water Source in this JICA project is upgradient of Ulaanbaatar City so the possibility of pollution is low in this area. However the central water sources located of the center of the City and the industrial/meat complex water sources located of downgradient of the City are deemed to that a high potential for pollution.

USAG is examining water quality of both water supply and sewerage and has achieved a basic understanding of the technology. However, USAG does not have an experience of environmental monitoring, which is conducted at present by the environment administration in Ulaanbaatar City. The soft component of the water quality monitoring is necessary to ensure the maintenance of the quality of the water sources.

### 5) Public relations improvement

The tariff system in Ulaanbaatar City was previously a flat rate system. The consumer was charged the same rate, regardless of the quantity of water consumed. Therefore, customers frequently did not repair broken plumbing and there was no incentive to practice water conservation.

Currently, USAG and OSNAAG which supplies water directly to apartment residents are proceeding the campaign of customer's water conservation. This campaign was undertaken because of the shortage of water corresponding to the increase in urban population, the increasing cost for water resource development and the development possibility of extra water source capacity of Tuul River is not enough.

A progressive water rate system has been adopted, and the installation of water meters has proceeded. One water meter is installed on the first floor of the apartment building, and the cost is shared by all of the residents of the building. A resident that pays to have a meter installed at the individual apartment unit receives a discounted rate. Through the implementation of the public awareness campaign and the progressive water rate system, per capita water consumption is decreasing.

To date, the emphasis has been placed on meter installation. Insufficient efforts have been made to increase public awareness of the benefits of water conservation. Also, disposal of construction debris and garbage and grazing of animals are occurring in the water source area. It is necessary to increase the level of awareness and understanding of water source preservation.

USAG needs assistance in the development of creative teaching materials to increase public awareness about the need for water conservation and preservation of the water sources.

## (2) Expected Result

### 1) Business structure strengthening

The development of a simulation model of the price calculation will yield the following results:

- different factors and their significance in establishing the price can be understood
- model provides an appropriate explanation of the price
- model will increase the level of understanding of the management of USAG, which is important for planning and cost control

### 2) Efficiency increase of water supply facilities operation and management

The Upper Water Source will utilize 55 wells. The transmission pump to the Zavsariin reservoir will be controlled by a level signal transmitted by radio to the pump station. A system should be developed to optimize utilization of the various wells. The system should consider cost optimization and water quality of each water source, given the variable costs and water quality of the different water sources.

The development of an operation manual for the system will provide the following benefits:

- optimization of operation and the management of the Upper Water Source wells, the transmission pump station and the Zavsariin reservoir
- improved efficiency in utilization of the existing water sources (central source, industry source, meat complex source).
- improved reliability of water supply and quality of service in cases of poor water quality or equipment malfunctions

### 3) Leakage detection

The development of a leakage investigation plan and improvement in the understanding of leakage will provide the following benefits:

- increase in technical knowledge and expertise
- implementation of a systematic leakage investigation and a deliberate leakage repair.

### 4) Environmental water quality monitoring

Water resource management plan will be prepared including the following items:

- ger drainage monitoring
  - ✓ an effective water quality items
  - ✓ effective monitoring points
  - ✓ sampling and analysis frequency
  - ✓ accumulation of the monitoring data
  - ✓ a water quality and countermeasures that are related both monitoring location and water source.
- Monitoring plan on water source and supplied water

  Existing technique is reviewed by the following:

- ✓ water quality items, sampling, frequency, location
- ✓ efficient way of USAG laboratory facilities and outside consignment

- Feedback

Compatible method (the plan) of the following item is shown.

- ✓ The reflection to the intake management (intake stop and so on of partial water source)
- ✓ The cooperation with the organizations of lower reaches (the end) such as the OSNAAG
- ✓ The way of cooperating with the environmental department

#### 5) Public relations improvement

A reduction in the amount of water wastage is essential in addition to the development of the new water sources. Therefore, the consumers must be taught the importance of water conservation. USAG needs to have a manual that provides information that can be used for distribution to consumers, and public relations techniques to increase understanding of the importance of water conservation.

Preservation of the quality of the groundwater source is important in for ensuring the safety of the water supply. Information and materials are required that identify the measures that are necessary to protect groundwater quality. These materials can be distributed and used to increase awareness about the activities that can damage the quality of water in the aquifer. This will result in the following:

- deeper understanding by users the water supply
- increased consciousness of water conservation
- increased understanding of the need for water source quality preservation

### (3) Activity (Investing Plan)

All of the soft components will be implemented by the cooperative work of the Japanese consultant and USAG staff.

Table 2-24 Plan On Activity (Investing Plan)

<table>
<tr><th>Item</th><th>Way of implementing</th><th>Number of people</th><th>Period time</th><th>Result</th></tr>
<tr><td>Business structure strengthening</td><td rowspan="5">Sending technical expert</td><td rowspan="5">Total 7 M/M</td><td rowspan="5">June-August, 2005</td><td>Water tariff calculation model</td></tr>
<tr><td>Efficiency increase of water supply facilities operation and management</td><td>Operation manual on upper water source facilities.<br>Guidance for effective water supply system operation</td></tr>
<tr><td>Leakage detection</td><td>Basic technology information<br>Leakage investigation plan</td></tr>
<tr><td>Environmental water quality monitoring</td><td>Monitoring plan</td></tr>
<tr><td>Public relations improvement</td><td>Materials for information awareness</td></tr>
</table>

### 2-2-4-7 Implementation Schedule

Because construction work cannot be undertaken in the winter season, the total time required for implementation is 32.5 months including 22 months of procurement and construction, 7.5 months of detailed design and 3 months of bidding.

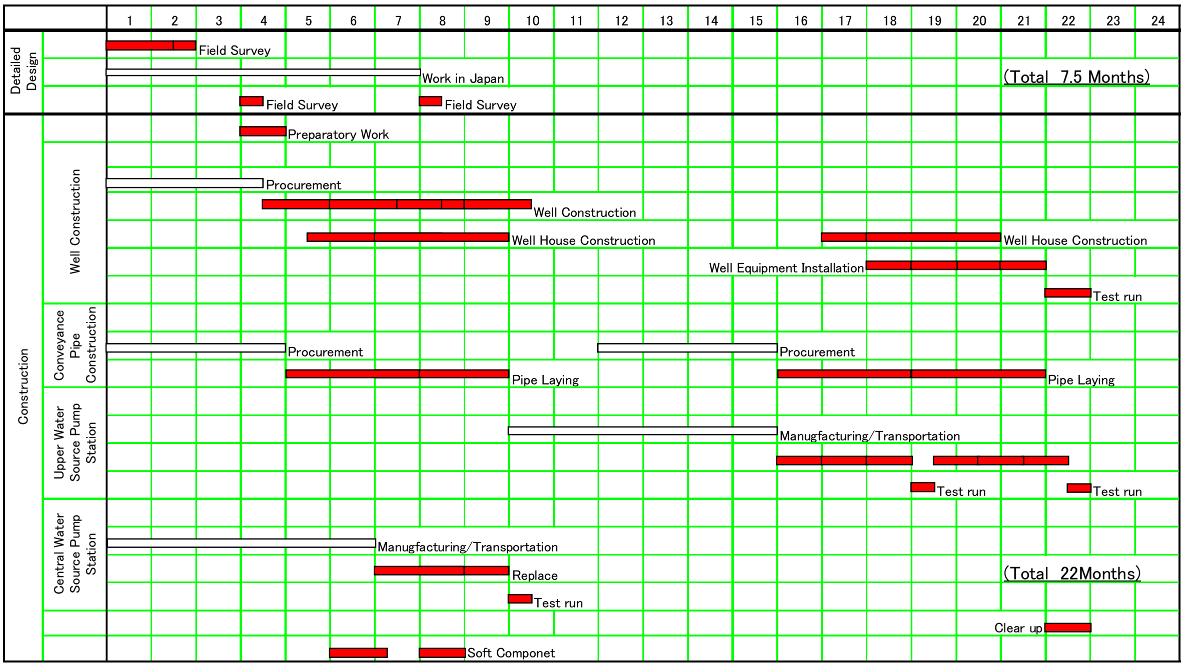



Figure 2-27 Implementation Schedule

## 2-3 Obligations of recipient country

The items that the Mongolian government and USAG will be required to implement are shown in Table 2-22, and listed below:

a. Installation of insulation material for well pump facilities:

Existing wells: 39 sets

New wells: 16 sets

b. Acquisition of land:

New wells: 16 sites

Water pipeline: approximately 13 km

c. Construction of fence:

New wells: 16 sites

d. Construction of power transmission line:

New wells: 16 sites

e. Removal and disposal of pumps located in existing pump station:

Upper Water Source Site: 6 sets

Central Water Source Site: 2 sets

## 2-4 Project Operation Plan

The facilities that will be constructed or upgraded in this project are:

- construction of sixteen intake wells/pumps at Upper Water Source
- replacement of two distribution pumps at Central Water Source
- replacement of six transmission pumps at Upper Water Source

Because USAG has enough personnel at present to operate and maintain the existing Russian pumps, the operation and maintenance of the upgraded facilities will be performed by the existing staff. For the sixteen intake wells/pumps that are constructed in this project, the following plan will be adopted.

The current staff consists of eight people working by split shifts ( four days each shift). Since they operate thirty-nine wells, one person is required for each five wells. Additional staff will be required three people for remote control management of the new sixteen wells.

For the Zavsariin reservoir, which is being improved under World Bank project (completion in December 2003), the work duties of management person and boiler operation should be combined with those of the Upper Water Source division. The responsibility for monitoring the water level in the reservoir (radio transmission) should be assigned to the two people (with clout over the military). The responsibility for operation of the disinfection equipment will require four people. Two additional people should be added for other duties at the Zavsariin reservoir. These workers should work under the split shift system that is used at the Upper Water Source.

Accordingly, the additional staff for operation/maintenance of this project is nine additional persons. The additional personnel is three for the well operation, of intake pump in Upper Water Source, four for the Zavsarriin reservoir disinfection equipment, and two additional personnel for the Zavsariin reservoir. The current operation and maintenance staff, and the required staff after implementation of this project are shown in Table 2-25.

Table 2-25 Operation/Maintenance Staff of Upstream Water Source Division

| | Present | After implementation of this project | Remarks |
|---|---|---|---|
| **<Facilities>** | | | |
| Intake pump station on Upper Water Source | 39 wells | 55 wells | Increase of 16 positions |
| Transmission pump station on Upper Water Source | 6 pumps | 5 pumps | It reduces to 5 upgraded pumps from 6 old pumps. |
| The Zavsariin reservoir | - | 1 item | World Bank Project |
| **<Job description>** | | | |
| Management person responsible for upper water resource | 1 person | 1 person | |
| Electric chief engineer | 1 person | 1 person | |
| Well remote control management | — | 3 persons | Increase by 3 |
| Well repair man | 6 persons | 6 persons | |
| Well electrician | 3 persons | 3 persons | |
| Well machinist | 2 persons | 2 persons | |
| Well management/operation section | 8 persons | 8 persons | |
| Pump operation section | 8 persons | 8 persons | (24 hours) |
| Pump repair man | 2 persons | 2 persons | |
| Pump electrician | 2 persons | 2 persons | |
| Common worker | 2 persons | 4 persons | Increase by 2 |
| Welder | 1 person | 1 person | |
| Boiler machinist | 1 person | 1 person | |
| Plumber | 4 persons | 4 persons | |
| Boiler Operator | 8 persons | 8 persons | (24 hours) |
| Disinfection equipment Section | - | 4 persons | Increase by 4 |
| Total | 49 persons | 58 persons | Increase by 9 |

## 2-5 Project Cost Estimation

### 2-5-1 Project Costs

The total project cost required if this project is implemented as planned by Japanese grant aid amounts 1,702 million yen. The cost breakdown based on the share works between Japan and Mongolia is shown in below. The basis of this cost estimate is the execution of the work described in Section 3. However, this estimated cost does not mean the limited amount to be provided in grant aid by mentioned in exchange notes.

## (1) The Project Cost borne by Japan Side

The total estimated cost Approx. 1,685 million yen

Table 2-26 Cost by Japanese Side

| Item | | Cost（million yen） | |
|---|---|---|---|
| Facility | （Construction）<br>Wells and well houses construction, Conveyance pipe construction | 785 | 1,511 |
| | （Replacement）<br>Transmission/distribution pump station facilities improvement | 719 | |
| Equipment | Hot insulation material | 7 | |
| Detailed design, Construction supervision and Soft Component | | 174 | |

## (2) The Cost by Mongolian Side

| | |
|---|---|
| 1) Well pump fence construction | 108,800,000 Tg |
| 2) Well pump electric power cable construction | 49,300,000 Tg |
| 3) Pump removal | 6,400,000 Tg |
| 4) Well pump hot insulation material installation | 2,530,000 Tg |
| Total | 167,030,000 Tg |

## (3) Cost Estimation Conditions

① Initiation date: Nov 2003

② Exchange rate:

Yen/US$: 1US$= 116.79 Yen

Yen/local currency: 1Tg =0.1018 Yen

### 2-5-2 Operation and Maintenance Costs

#### (1) Operation and Maintenance Costs

The operation and maintenance costs are shown in Table 2-27. The operation and maintenance costs will change because of increased personnel and increased system capacity. The operation costs will also change due to reduced energy consumption by the more efficient replacement pumps. It is estimated that the existing intake capacity is 222,000 cu. m/day, and that the increase in capacity resulting from implementation of this project is 18, 000 cu. m/day.

Table 2-27 Operation and Maintenance Cost
(Capacity increase: 18, 000 cu.m /day).

| Item | Computation | O & M cost (thousand Tg/year) | Remarks |
|---|---|---|---|
| Personnel cost (Increase) | - 3 pers. (well remote control management) x 789,000(Tg/year/pers.) = 2,367,000<br>- 4 pers. (disinfection equip.) x 777, 000(Tg/year/pers.) = 3,108,000<br>- 2 pers. (common worker) x 729, 000(Tg/year/pers.) = 1,458,000 | 6,933 | Intake pump station and the Zavsariin reservoir |
| Electric power cost (Increase) | - Intake pump station of Upper Water Source (Increase: 16 wells)<br>Electric power cost: 18.5/1.15 x 15 x 0.863 x 24 x 365 x 47(Tg/kwH) = 85,739,000 (Tg/year)<br>- Transmission pump station at Upper Water Source (quantity of water increase)<br>Electric power cost: 18,000 x 0.42 0.863 x 365 x 47(Tg/kwH) = 111,924,000 (Tg/year)<br>- Heater for freeze prevention (Increasing: 16 wells)<br>Electric power cost: 0.3 x 16 x 24 x 120 x 47Tg/kwH = 649,728 (Tg/year) | 198,313 | Upper Water Source |
| Maintenance cost (Increase) | - Mechanical equip.: 0.5 %/year of equipment cost<br>4,380,000, 000(Tg)×0.005 = 21,900, 000 (Tg/year)<br>- Electric equip.: 0.2%/year of equipment cost<br>1,700,000, 000(Tg)×0.002 = 3,400, 000 (Tg/year) | 25,300 | |
| Total (Increase) | | +230,546 | A |
| Electric power cost (Decrease) | - Electric power cost reduction by upgrading distribution pump station at central water source. (difference in electric power cost)<br>67,000 x {(0.28 + 0.39 x 2) /3 – 0.28} x 0.863 x 365 x 47(Tg/kwH) = 72,741,000 (Tg/year)<br>- Electric power cost reduction by upgrading (39) heaters for freeze prevention (Difference of electric power cost)<br>(6.0 – 0.3) x 39 x 24 x 120 x 47(Tg/kwH) = 30,091,000 (Tg/year) | -102,832 | Upgrade two pumps<br>B |
| Net Increase | | +127,714 | = A – B |

Actual operation and maintenance costs for water supply by USAG in 2002 are shown in the following table.

Table 2-28 USAG Operation and Maintenance Costs

| **Item** | **O/M Cost Breakdown (1000Tg)** | **Percent of Total Cost (%)** |
|---|---|---|
| Personnel cost | 872,891 | 25.6 |
| Electric cost | 2,178,038 | 63.9 |
| Fuel cost | 234,602 | 6.9 |
| Maintenance cost | 122,115 | 3.6 |
| Total | 3,407,646 | 100.0 |

USAG's operation and maintenance costs were 3,407 million Tg in 2002 according to above table. The estimated additional operation and maintenance costs with the increased capacity of 18,000 cu. m/day are estimated to be approximately 128 million Tg, which is an increase of approximately 3.8% of the current operation and maintenance costs of 3,407 million Tg.

The estimated additional income that will be realized through the delivery of the additional 18,000 cu. m/day, based on the wholesale unit price of 133.8 Tg/cu. m to the OSNAAG in 2003, is as follows:

> 18,000 (cu. m/day) x 0.86 x 0.9 x 365(day/year) x 133.8(Tg/cu. m) = 682,770,562 Tg/year, or approximately 683 million Tg/year

The increased additional income is greater that the increased operation and maintenance costs. The net increase in income is 683 –128= 555 million Tg/year. This is equivalent to approximately 45% of the deficit on USAG Profit and Loss Statement

### (2) Facility/Equipment Duration Time

The facilities will be depreciated over the number of years according to the standard periods used in Mongolia. The useful life of the facilities is as follows:

- intake pump station building: 80 years
- well facilities (excluding pump equipment): 20 years
- pump equipment: 21 years