CHAPTER 2. Contents of the Project

2－1. Basic Concept of the Project

2－1－1. Overall Goal and Project Objective

Myanmar has set up, as a part of the First National Development Five Year Plan (year 2011 ~ 2015), a) the various reforms (political, economic, administration and private sector development), b) the nation-centered development and c) the top 10 prioritized development areas (industry, energy, electricity, communication, transportation, fundamental health, education improvement, social security, water supply system and rural development/poverty reduction). This Project is considered as belonging to water supply sector among the top 10 priorities development areas listed in item c) above.

This Project aims at coping with increase in the water served population and ensuring safe supply of tap-water by developing a new water supply system for Pyi Gyi Tagon TS in Mandalay City and by introducing chlorine disinfection facilities in the existing water supply system in the Mandalay City. The Project is therefore expected to contribute to the improvement of sanitary condition and living environment for the inhabitants through this development and improvement Project.

2－1－2. Outline of the Project

To achieve the overall goal of the Project, the input of the Japanese side will be financial assistance for the construction of the water supply facilities and engineers for the design and construction of these facilities. The input of the Myanmar side will be finance for the operation and maintenance of facilities constructed in the Project, the electricity supply feeder for the Project facilities, the counterpart engineers of implementation agency, etc. The Project activities to be implemented are listed below. Through implementation of the Project, it is expected that the water served population and the water supply rate in Pyi Gyi Tagon TS will be increased and water disinfected by chlorine will be supplied to the existing water supply areas in Mandalay City.

Project Activities

(1) Construction of new water supply system for Pyi Gyi Tagon TS

- Well water intake facilities using groundwater as main water source
- Water distribution reservoir and water distribution pump facilities
- Water transmission pipeline and water distribution pipeline network
- Chlorine disinfection facilities
- Fire hydrants and water service equipment

(2) Construction of chlorine disinfection facilities for existing water supply system

Chlorine (Sodium hypochlorite) generated facilities

Chlorine (Sodium hypochlorite) dosing facilities

2－2. Outline Design of the Japanese Assistance

2－2－1. Design Policy

2－2－1－1. Basic Policy

(1) Policy on the planned target year

The target year is set up based on the following considerations;

- The year of completion of the Project for the water supply system in Pyi Gyi Tagon TS is set as 2017 based on the draft implementation schedule. The planned target year is set as 2020, three years after completion of the Project.
- Once the distribution pipeline network is laid, diameter expansion work (corresponding to the increase in required water flow rate) will incur considerable losses economically since the cost for this work will be enormous. Therefore, the planned target year for distribution pipeline is further extended and is considered as 2025.
- The planned target year of disinfection facilities is set as 2017, the same year when the construction of the Project is to be completed. This is because the disinfection facilities will be planned for the flow rate of the existing water supply facilities.

(2) Policy on selection of Project components

The Project components recommended by JICA and implemented in the follow-up study in 2012 (hereafter referred to as “FU study”) were a) expansion of the water supply system for Pyi Gyi Tagon TS and Chan Myar Tharzi TS and b) introduction of the chlorine disinfection facilities for all the existing water supply system. Subsequently, JICA held discussion with the Myanmar side on the recommendations. Based on the outcome of the discussions, the Project components were decided as described below.

Although, Pyi Gyi Tagon TS is expected to be developed further with the establishment of the industrial park, etc., it still suffers from poor services and living environment such as, low water supply coverage, high poverty rate of the inhabitants, high rate of occurrence of water borne diseases, etc. Therefore, the supply of safe water in the Pyi Gyi Tagon TS is considered as the first priority and the construction of the water supply system is narrowed down to Pyi Gyi Tagon TS.

Initially, the chlorine disinfection facilities were considered to be introduced in the existing water supply system at 10 places except for No. 8 water treatment plant that is being constructed

newly. These 10 locations included: BPS No. 1, 2, 3, 5, 6 & 7, Mandalay Hill reservoir, No. 4 water treatment plant, and No.1 & 2 elevated water tanks. But after the FU study, the chlorine disinfection facilities for No. 4 water treatment plant were decided to be implemented under the Japan's grassroots technical cooperation. Finally, the installation of chlorine disinfection facilities is considered at only 9 locations under this Project.

In case water is distributed without disinfection through the water supply system, this will lead to problem related to water quality safety and sanitation. Therefore, prior to this Project, Kitakyushu city implements the project for construction of the chlorine disinfection facilities in No. 4 water treatment plant and carries out capacity development of relevant counterpart engineers for operation and maintenance under the Japan's grassroots cooperation project. Under this Project, application of the same chlorine disinfection system, as used in case of No. 4 water treatment plant, is planned considering smooth operation and sustainable maintenance of new facilities.

(3) Policy on selection of the target area of water supply system for Pyi Gyi Tagon TS

The target area of the Project is selected in accordance with the flowchart illustrated below

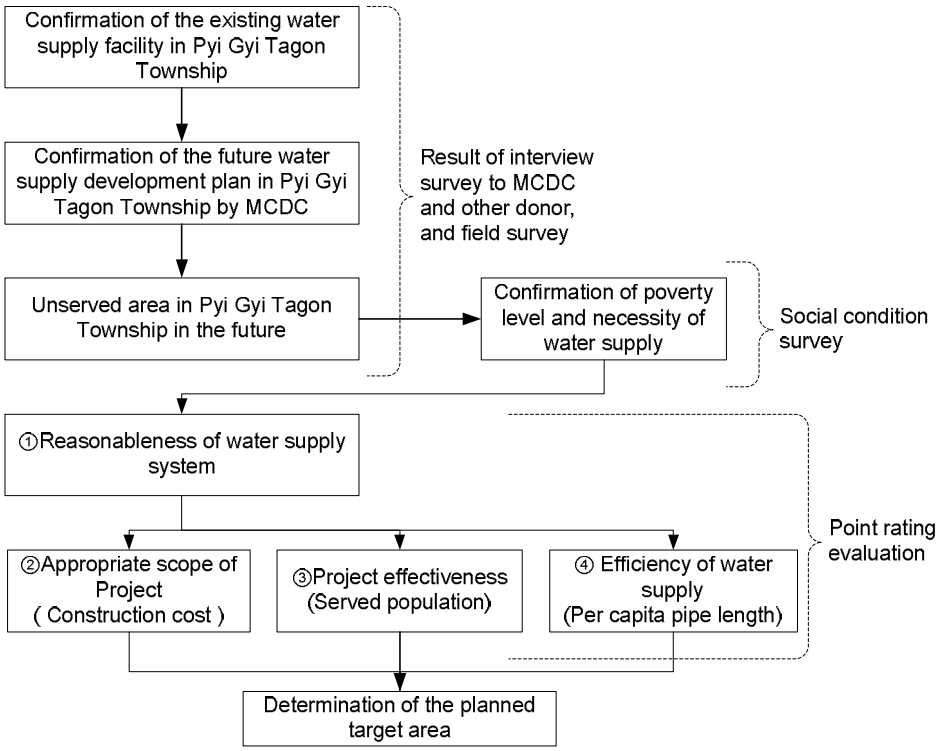


Figure 2-1 Flowchart of selection of the planned target areas

As mentioned above, first of all non-served water supply area (existing or in future) in Pyi Gyi Tagon TS was identified upon discussion with the MCDC. Subsequently, it was confirmed if the degree of poverty in these area is higher than in the other areas in Pyi Gyi Tagon TS and whether the level of difficulty of providing water supply services is greater than in other areas of this township. The evaluation of these non-served areas is carried out through scoring based on the criteria such as

rationality (reasonableness) of water supply system, project scope, project effect, water supply efficiency, etc.

Finally, MCDC Water & Sanitation Department and the JICA Study Team discussed five proposals for water supply service areas as shown in figure below, and the appropriate Project area was selected.

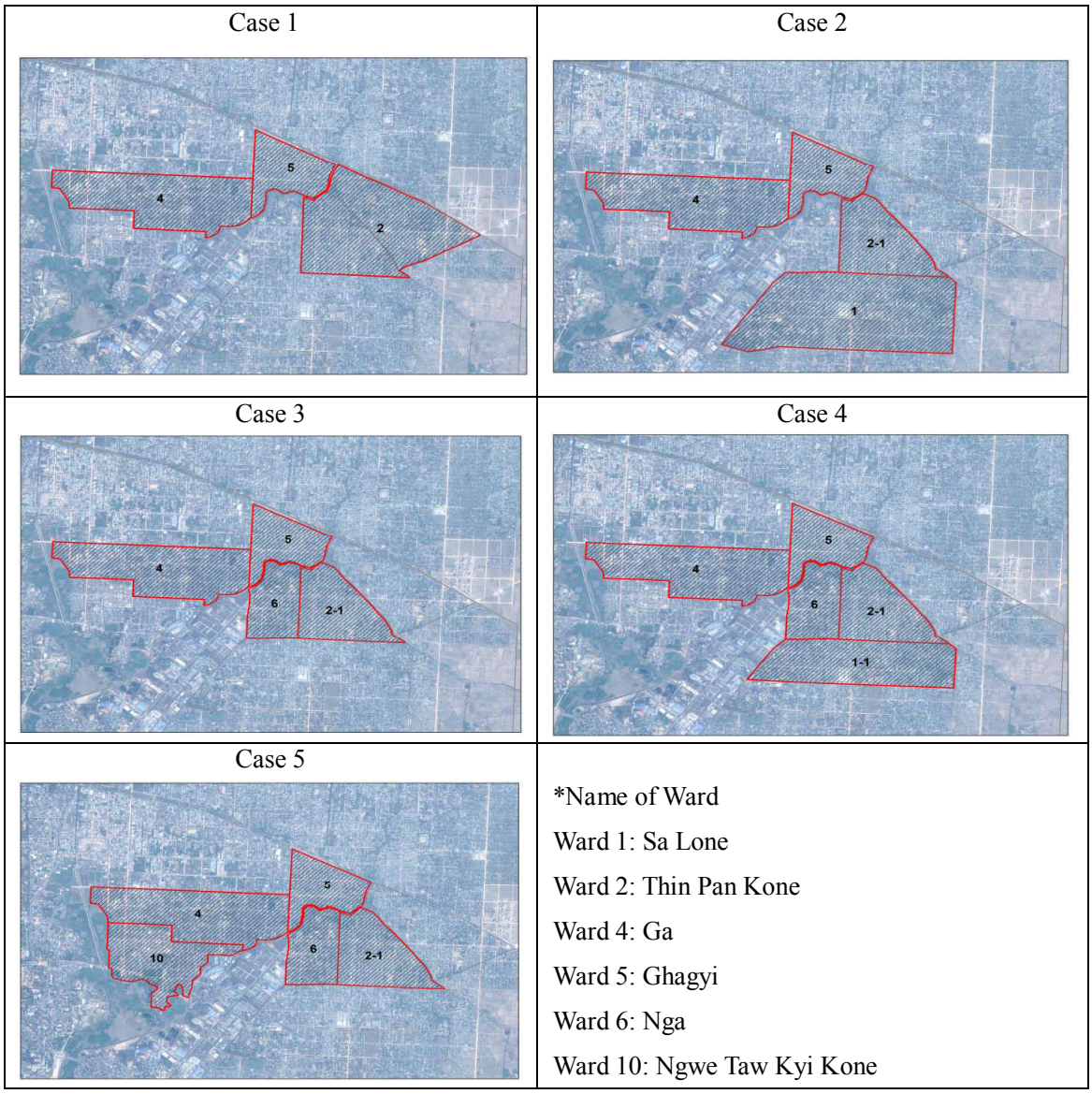


Figure 2-2 Proposed service area by MCDC

To select the planned target water supply areas in this plan, the five proposals mentioned above were evaluated considering the following criteria:

1) Reasonableness of water supply system

For the water supply development plan of Pyi Gyi Tagon TS, MCDC plans to divide the area into three parts: area where water supply has already been implemented by MCDC itself, areas to be

developed under Japanese grant aid cooperation scheme, and areas to be developed by the water supply system using surface water. The decision on service areas in this plan is closely associated with the scope of the plan; MCDC has discussed with JICA Study Team about the areas while considering the scope of the plan. The reasons for selecting the five proposals are valid, and these proposals were assessed in the order of reasonableness through assignment of ranking scaling from 1 to 5 (1-highest, 5-lowest).

Table 2-1 Assessment of proposals by reasonableness of water supply system

Case	Outline of selected target area	Evaluation	Ranking
1	Select wards are located in the northern part in the Pyi Gyi Tagon TS excluding service areas already served by MCDC. However, population density is low in the middle of Ward 2 to the east of the drainage canal. Ward 10 and Ward 6 at the center are not included in the service area.	Distribution pipelines will pass through existing service areas when drafting the water supply plan to Ward 10 in the future; therefore, providing these pipelines now will be uneconomical. Although provision of water supply may be more uneconomical than in Case 5, water supply to unserved areas can be implemented more efficiently than in Case 2, 3, and 4.	2
2	Excludes the part east of the drainage canal from the middle of Ward 2 compared to Case 1; entire Ward 1 area is added.	Distribution pipelines will pass through existing service areas when drafting the water supply plan to Ward 10, Ward 6 and the eastern part of Ward 2 in the future; therefore, this is uneconomical. This may be the most uneconomical of all the proposals, so assessment is the lowest among all the proposals.	5
3	Excludes the part east of the drainage canal from the middle of Ward 2 compared to Case 1; entire Ward 6 area is added.	Distribution pipelines will pass through existing service areas when drafting the water supply plan to Ward 10 and the eastern part of Ward 2 in the future; therefore, this is uneconomical. Although more uneconomical than Case 1, efficient divisions can be made by setting boundaries for the service area, such as by structures like drainage canals and by terrain.	3
4	Include northern areas (half of Ward 1) in Ward 1 to the areas of Case 3.	Distribution pipelines will pass through existing service areas when drafting the water supply plan to Ward 10 and the eastern part of Ward 2 in the future; therefore, this is uneconomical. Ward 1 is divided into two parts. Since it cannot be divided efficiently by structures such as drainage canal or by terrain, the residents are likely to express dissatisfaction.	4
5	Ward 10 is added to the areas of Case3.	Although providing distribution pipelines passing through existing service areas when drafting the water supply plan to the eastern part of Ward 2 in the future will be uneconomical, a separate water pipe route can be ensured (same for Case 2, 3 and 4). This is a proposal in which water can be supplied with the best efficiency to unserved areas in the future.	1

2) Appropriate scope of project

The construction cost of the distribution system (distribution pipeline network) was estimated to evaluate the appropriateness as scale of the project. The approximate cost for constructing distribution system in each of the 5 proposals was estimated. Setting the lowest construction cost of the five

proposed cases as 100, the construction cost of all other cases were categorized into three ranks based on 100 and given a score as shown in the table below.

Ranking of rate of construction cost (%)	100 - 110	111 - 120	121 - 130
Score	3	2	1

Evaluation result is enumerated in following table.

Case	1	2	3	4	5
Score of construction cost (%)	110	129	100	126	111
Evaluation	3	1	3	1	2

3) Project effectiveness

The served population is a project effect indicator. As the benefits of implementing this Project to the served population increase, so do the project effects; therefore, the evaluation was made in the increasing order of served population. The evaluation points were doubled since this criterion is an important factor in project planning.

4) Efficiency of water supply

When the total length of distribution pipeline is divided by the population, the distribution pipeline length per capita can be calculated. Water supply can be accomplished with short pipeline lengths in areas that have high density of population. The range of per capita pipe length in this comparative proposal is 2.03 m to 2.48 m. Therefore, these values were evaluated in three categories with ranges: below 2.20, 2.20-2.40, and above 2.41. Scoring is carried out with 1, 2 or 3 points for each category.

The table below shows the results of overall assessment.

Table 2-2 Evaluation of the proposed service area

Case	(1) Reasonableness of water supply system		(2) Appropriate scope of the Project	(3) Project effectiveness		(4) Efficiency of water supply		Total score	Rank
	Ranking	Score 【5】	Score 【3】	Population served (persons)	Score 【10】	Pipe length per capita (m)	Score 【3】		
Case 1	2	4	3	42,599	4	2.14	3	14	**2**
Case 2	5	1	1	48,257	10	2.47	1	13	**3**
Case 3	3	3	3	37,052	2	2.13	3	11	**4**
Case 4	4	2	1	44,764	6	2.48	1	10	**5**
Case 5	1	5	2	46,781	8	2.03	3	18	**1**

Note: 【】indicates maximum score of each evaluation item

(4) Policy on water source for Pyi Gyi Tagon TS

According to the Master Plan (M/P) of "The Study on Water Supply System in Mandalay City and in the Central Dry Zone in the Union of Myanmar" implemented by JICA in year 2001 to 2003, the developable amount of groundwater since year 2002 is 48,000 m^3/day (from the wells in the northwest area in Mandalay city: 26,000 m^3/day, and from the wells in the southern area: 22,000 m^3/day). Subsequently, in the follow-up study implemented by JICA in year 2012, it was assessed that the groundwater recharge amount from Irrawaddy River may be expected more than the amount estimated in M/P. Also, as for the developable volume of the wells in the northwest area, it was assessed that the development of the groundwater having about 9,000 m^3/day necessary for this Project would be feasible.

The utilization of groundwater for the small-scale water supply system targeted under this Project is more advantageous than the use of surface water considering the technical and economic aspects as explained below.

- From the technical aspect, water quality in case of groundwater is good even without any specific treatment except for disinfection. Currently the surface water of Irrawaddy River, Doktetawaddy River running through the southern part, etc., which MCDC uses as water source for a part of water supply system, have high turbidity over 5 mg/L (the drinking water quality standard for turbidity in case of Myanmar) throughout the year. Therefore it requires water treatment and disinfection. On the contrary, the groundwater can be used as drinking water after disinfection only.
- From the economic aspect, the construction cost is much less than that of water treatment system for surface water and laborers required for operation and maintenance are less since the system is simple. Moreover, chemicals such as coagulation agent are not required to remove turbidity. Therefore, the initial investment cost and operation and maintenance cost of water treatment for groundwater use is less than that of water treatment system for surface water use. In addition, in case of use of the surface water, treatment of the sludge discharged from water treatment is required. From the initial and running cost aspect, the use of surface water requires additional cost and is higher than the case of use of groundwater.

From the above explanation, it is considered that the groundwater is most suitable as water source for the water supply system under this Project. The study and the policy on the groundwater as water source under this Project are described below.

1) Target aquifer

The geology and hydrogeology around BPS No.7 are classified as follows;

- The clay bed of the 3rd layer and the underlying predominant sand bed of the 4th layer can be identified just like the classification of the Quaternary system shown in the M/P survey.
- From the point of view of the hydrogeological unit, the 3rd layer is consistent with the confining layer and the 4th layer with the 3rd aquifer.

The M/P survey compiled hydrogeological constants as follows;

- The values of the main aquifer's hydraulic conductivity obtained through the hydrogeological survey were 220 m/d in the northwest area including the well field and 1.3 m/d in the southern area.
- This difference suggested that the northwest area has a six to eight-time higher potential of groundwater than the southern area. Each well's yield in the northwest area was estimated at about 5,000 m^3 per day and about 800 m^3 per day in the south area.

Many of the wells in the northwest well field have about 6m screen length. Transmissivity (T), which is calculated by multiplying the screen length (6m) and the above-mentioned hydraulic conductivity (220 m/d), is 1,320 m^2 per day.

In the target area, transmissivity values obtained through the pumping test that was conducted in the test well are 561 m^2/day (Theis equation), 1,138 m^2 /day (Cooper-Jacob equation) and 2,265 m^2/day (recovery method). However, the margin of error for the overlay of measured values on the Theis type curve is large, because of the smaller value of drawdown. So the transmissivity of the test well is estimated to be around 1,000 to 2,000 m^2/day and it is considered that the aquifers around the target area have the same ability as the aquifer in the northwest well field.

On the basis of the above-mentioned hydrogeological conditions, the 3rd aquifer (deep confined groundwater), which is a main aquifer of the two production wells in BPS No.7 premises and many wells in the northwest well field, is considered as the targeted aquifer for this groundwater development plan.

2) Estimation of optimal yield[6]

The optimal yield for an individual well is examined by using the following method (Tohoku Regional Agricultural Administration Office of the Ministry of Agriculture, Forestry and Fisheries, 2008)[7];

① The results of step-drawdown pumping test is approximated by a quadratic curve "$s=BQ+CQ^2$".

② After drawdown values are estimated using the equation above, the pump discharge when pumping water level is decreased to the pump position is defined as "Possible maximum pumpage". Sustainable amount of pumping rate of an individual well is estimated as less than or equal to this value.

③ Because the calculation of the above "possible maximum pumpage" is affected by the initial water level, it is necessary to take into account seasonal groundwater fluctuations to prepare a pumping plan.

[6] Refer to the Appendix 6-10 for the details of analysis.
[7] www.maff.go.jp/j/nousin/noukan/tyotei/t_seika/pdf/h20seika_10.pdf

The possible maximum pumpage is estimated to be 6,220m^3/day. Daily pumping rate based on the design water supply is 3,000 m^3/d/per well (estimated drawdown is 17.65 m) and it can be judged that this value (3,000 m^3/d) is a water amount that can be sufficiently and safely pumped.

3) Influence on the surrounding wells[8]

The possible maximum pumpage of an individual well is estimated as above. In addition, it is necessary to consider the influence on the surrounding environment as a result of the pumping.

Although Tohoku Regional Agricultural Administration Office (2008) proposed the consideration of the water budget of the entire groundwater basin, in the target area, sufficient data for performing the calculation of the water budget. Therefore, using a theoretical formula, ("Influence area of a single well (analysis method: Theis equation)" and "Drawdown volume around the new well development area (analysis method: deformation of the Cooper-Jacob equation)") are predicted.

Three sites in the scenario 1 in the table below are selected the new intake facility construction candidates taking into consideration of the prediction of the drawdown volume around the pumping wells and easiness of land-use permission.

Table 2-3 Scenario of new well development plan (○: Development candidate sites)

No.	New well candidate sites	Scenario 1	Scenario 2	Scenario 3	Scenario 4
1	Next to Martyr memorial (Test drilling point)	○ 3,000m^3/day	○ 3,000m^3/day	○ 3,000m^3/day	○ 2,250m^3/day
2	Play ground Next to transformer station	○ 3,000m^3/day	—	—	○ 2,250m^3/day
3	In front of Yinn Taw, Su Taung Pyae Pagoda, Aung Myay Bon San Ka Toe Kyaung, side by KOICA well	—	○ 3,000m^3/day	—	—
5-3	Behind the New Day gas station, near Sanda Mon Pagoda	○ 3,000m^3/day	○ 3,000m^3/day	○ 3,000m^3/day	○ 2,250m^3/day
8	Park in front of BEHS (7)	—	—	○ 3,000m^3/day	○ 2,250m^3/day

Note: For scenarios, refer to Figure 2-3

4) Assessment of appropriateness of test well as water source in terms of water quality

Water quality test was conducted in terms of 36 parameters, including Nitrate, Nitrite, Arsenic, Fluorine, Metals, Total coliforms and Fecal coliforms to assess the appropriateness of test well as water source.

In this water quality test, Arsenic, Nitrite and Nitrate which have an adverse effect on human health were not detected. Fluorine was detected with the concentration of 1.1 mg/L. The WHO-GL value for drinking water quality on Fluorine is defined as 1.5mg/L. Iron was detected with the concentration of 0.09 mg/L and Manganese concentration was 0.05mg/L. Iron and Manganese are

[8] Refer to the Appendix 6-10 for the details of analysis.

dominant items related to aesthetics of water (color or taste). The concentrations of Iron and Manganese are within the defined limits of the existing MCDC and Japanese water quality standards.

Based on these results, this test well was assessed as a suitable water source for drinking water supply in terms of water quality. However, Fluorine should be continuously monitored.

The basic policy of the groundwater development of this plan based on the results above is as follows;

- Target aquifer: 3rd aquifer (deep confined groundwater) is the target of the water sources development.
- Development yield: Design water supply (9,000 m^3/d) is to be provided by three wells with the pumping amount of each well as 3,000 m^3/d. However, the amounts of groundwater to be developed and pumped for each well are to be finally determined based on the results of the pumping test of multiple well system that will be carried out after the construction of all wells.
- Production wells: Three sites of scenario 1 in the Figure 2-3, will be selected as candidates for the new intake facility to be constructed.
- Well drilling sites: For the above-mentioned intake facilities, new well drilling will be performed at two sites in addition to a test well drilling site.
- Groundwater monitoring: The far-reaching influence and the occurrence of the drawdown of 10 m or more around the pumping wells are predicted although this estimation result is the theoretical maximum value without the recharge parameter. For this reason, a soft component related to the groundwater monitoring system mentioned later is proposed. Moreover, one groundwater monitoring well for the purpose of groundwater level measurement will be constructed on BPS No.7 premises or surrounding area.

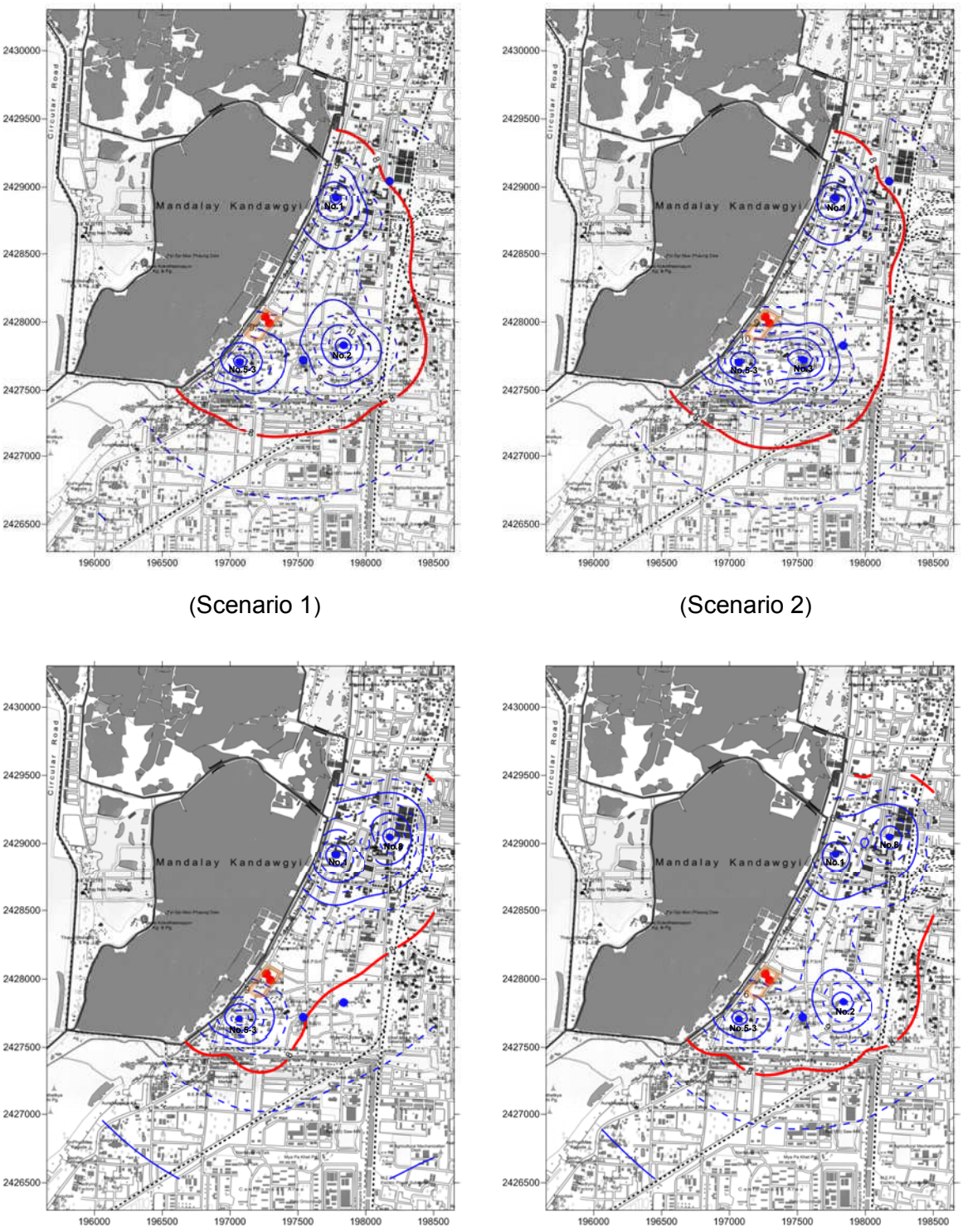


Figure 2-3 Comparison of predicted drawdown volume due to new well development (20 years after the start of pumping)

(Refer to Table 2-3 for details of numbers in the figure. ●: Existing production wells managed by MCDC)
(Contour line of groundwater drawdown of 8 m is shown as a red line for comparison)

(5) Other policies related to planning of water supply system for Pyi Gyi Tagon TS

MCDC has no guidelines related to design of the water supply system. In this Project, the planning of water supply system is based on the design specification shown in "Design Criteria for Waterworks Facilities" by Japan Water Works Association and plan is prepared taking into consideration the current conditions of Mandalay city.

The design is prepared taking into consideration that the facilities can be operated and maintained easily and sustainably, and are economical. The materials/equipment specifications are prepared so as to satisfy the international standards such as ISO, etc.

In the planning and design of the water supply system, consideration is given to the poverty level of customers as described below. The operation and maintenance cost such as cost of chemicals required to treat the water and electrical charges can be restrained by use of ground water as water source. A high value of operation and maintenance cost leads to increase in the water tariff in future, any reduction in these costs can contribute to avoiding any increase in the water tariff.

Also, the house connection work for the water supply facilities is included in the scope of Japan grant aid cooperation as far as possible to reduce burden on the inhabitants.

Following the above two policies, reduction of burden on the poor classes in the form of avoiding any increase in their expenses on water services has been tried to achieve.

(6) Policy related to the plan for chlorine disinfection facility

1) Location of installation of disinfection facilities

Mandalay City has water supply facilities at nine locations with systems consisting of: wells-distribution reservoir-pumping stations or elevated water tanks using groundwater. It also has water supply facilities at two locations with systems consisting of river intake - water treatment plant - pumping station using surface water presently. Disinfection facilities have already been constructed by MCDC at the existing No. 8 water treatment plant using surface water. Disinfection facilities will be constructed under the Japan's grassroots technical cooperation scheme (Kitakyushu City) at the No. 4 water treatment plant. Therefore, in this Project disinfection facilities are proposed to be installed at the following nine locations of existing water supply facilities.

- No. 1 pumping station (BPS No. 1)
- No. 2 pumping station (BPS No. 2)
- No. 3 pumping station (BPS No. 3)
- No. 5 pumping station (BPS No. 5)
- No. 6 pumping station (BPS No. 6)
- No. 7 pumping station (existing facility) (BPS No. 7)
- Mandalay Hill distribution reservoir (No. 28 well)
- No. 1 elevated water tank (ET No. 1)

- No. 2 elevated water tank (ET No. 2)

The Mandalay Hill distribution reservoir above has two kinds of water sources—ground water from well fields (No. 28, No. 29, and No. 30) and treated water from the No. 8 water treatment plant. Treated water from the No. 8 water treatment plant is disinfected at the water treatment plant; therefore, only ground water from the well field (well No. 28) will be disinfected under the Project. (Hereinafter, Mandalay distribution reservoir is listed as No. 28 well in the chlorine dosing facilities).

2) Design policy for disinfection facilities

Regarding the water supply from existing water supply facilities managed by MCDC, the disinfection facility constructed by ADB in 1994 suffered a leakage accident, and since then drinking water has not been disinfected. The result is that standard plate count bacteria have been detected in water being distributed and supplied. Moreover, fecal coliform has been detected in samples from all facilities except the Mandalay Hill distribution reservoir. If either standard plate count or fecal coliform is detected in the water supply, contamination of the supplied water by intestinal pathogens occurs and will become a hygiene problem for inhabitants. The results of water quality tests of collected samples conducted during the preparatory study of this Project are shown in the table below.

Table 2-4 Result of water quality test and chlorine demand

Sampling point	Standard plate count	Fecal coliform			Chlorine demand (mg/L)	
	Reservoir	Reservoir	Water tap (1)	Water tap (2)	Experimental value	Theoretical value
BPS No.1	Pos.	Pos.	Pos.	N.D.	0.263	0.293
BPS No.2	Pos.	N.D.	N.D.	Pos.	0.335	0.332
BPS No.3	Pos.	Pos.	Pos.	N.D.	0.129	0.205
BPS No.5	Pos.	Pos.	N.D.	Pos.	0.410	0.288
BPS No.6	Pos.	N.D.	Pos.	Pos.	0.304	0.217
BPS No.7	Pos.	Pos.	Pos.	Pos.	0.369	0.192
Well No.28 (Mandalay hill reservoir)	Pos.	N.D.	N.D.	N.D.	0.333	0.319
ET No.1	Pos.	N.D.	Pos.	Pos.	0.296	0.179
ET No.2	Pos.	Pos.	Pos.	Pos.	0.201	0.103

(Note: BPS:Booster Pump Station, ET Elevated Tank, Pos. Positive, N.D.: Not Detect)

From the above table, it is observed that chlorination is necessary for disinfecting these bacteria. According to the WHO Guideline, the factor of the residual chlorine must be considered for planning and design of water supply facilities. The target free available chlorine is set at more than 0.5mg/L 30 minutes after dosing at each dosing point, to keep residual chlorine during supply of water. The detail on setting of dosing rate of chlorine is described in 2-2-2(5). The options for chlorine-based disinfectants are given below.

- Chlorine gas (liquid chlorine)
- Sodium hypochlorite (commercial)
- Sodium hypochlorite (produced)
- Calcium hypochlorite (bleaching powder)

Chlorine gas is extremely toxic. If inhaled by mistake, it could damage the respiratory organs, or it may even cause death depending on the concentration of the gas inhaled. If the concentration is more than that present in the atmosphere, it causes strong irritation of the mucous membrane of the skin and respiratory organs and may lead to coughing or vomiting. Inflammation may occur in a body part that comes in contact with liquid chlorine; even a small leak poses risks to the operator and the residents nearby. Leakage occurred in 1994 in the facility in which wastewater to be sent to BPS No. 1 was being dosed with chlorine. Subsequently, chlorine gas has not been used by the MCDC. Chlorine gas was being produced in Myanmar while it was used in the facilities; it is no longer being produced in Myanmar presently, so it has to be imported.

If the temperature of liquid chlorine rises, its pressure and volume increase, and the container may be broken which cause leak from its container. The container should be kept below 40 ^{o}C. The average maximum temperature is30^{o}C but sometimes the temperature exceeds 38^{o}C. Mandalay City is located inland and away from the coast; therefore, imported chlorine unloaded from ships at Yangon City must be transported in special containers by cold-storage vehicles over a long distance while maintaining the chlorine gas at low temperatures. The cost required is high; moreover, handling risks while filling the cylinders are also high and operations are complex; so the use of chlorine gas is impractical. In view of the reasons above, and considering safety during use and at the time of procurement, chlorine gas will not be included in options.

Sodium hypochlorite (commercial) is also not being produced in Myanmar, and has to be imported. The effective chlorine concentration of hypochlorite changes with time and degrades; the rate of decrease in concentration accelerates with the rise in temperature. Since the effective chlorine concentration of sodium hypochlorite (commercial) is about 12% generally, its transportation efficiency is poor. Even if it is imported, the effective chlorine concentration is expected to decrease during the transportation period. In view of the above reasons, since chemical and transportation costs of sodium hypochlorite (commercial) are high, efficiency is likely to degrade, and track record or procurement of the same does not exist. Therefore, sodium hypochlorite (commercial) is not included as an option.

Bleaching powder is not produced in Myanmar as well; therefore it has to be imported. However, long transportation period is not an issue, the effective chlorine efficiency is also about 65% generally, and the transportation efficiency is very good. Moreover, sodium hypochlorite can be produced in Myanmar using raw salt. Raw salt, which is the raw material, can be procured in Mandalay City. Sodium hypochlorite generation equipment (non-diaphragm process) uses generally common salt as raw material. The content of sodium hypochlorite in common salt is more than 95% compared to 99.7% of fine salt. The content of sodium hypochlorite used in No. 8 water treatment plant is from 96.5% to 97.5%. It is more than 95% and it is judged that common salt can be used for sodium hypochlorite generation equipment.

In view of the explanation made above, sodium hypochlorite (produced) and bleaching powder are selected as chlorine disinfectants in this plan and one of these options is selected after comparison. The comparative study for these 2 options is given below.

Table 2-5 Comparison of sodium hypochlorite (produced) and bleaching powder

	Sodium hypochlorite (produced)	Bleaching powder
Chemical solution	After mixing the saturated salt solution obtained by dissolving raw salt with distilled water, it is supplied to the electrolyzing tank. It is electrolyzed to produce sodium hypochlorite solution with effective chlorine concentration of about 1%.	Bleaching powder is in powder form and is generated by absorbing chlorine in hydrated lime. Generally, it is used after dissolving it to obtain an effective chlorine concentration of 60-70%.
Procurement method	Raw salt or common salt, which is the raw material, can be easily procured in Mandalay City market; so there is no need to import it.	Bleaching powder is not being produced in Myanmar, so it has to be imported. It is comparatively stable in solid form, so it can be transported over long periods as well.
Operation and maintenance	−By setting up a production point, the produced sodium hypochlorite can be transferred to other water supply points and used, enabling better efficiency in O&M related to production of sodium hypochlorite. −Periodic acid cleaning of electrodes in the electrolyzing tank is required. −The vendor which can correspond to damage of equipment is necessary to select since sodium hypochlorite generation equipment mainly consists of mechanical and electrical equipment.	−Bleaching powder needs to be dissolved in all dosing points. O&M burden will fall especially on small-scale water supply points since there is only one operator. −Dissolving tank must be cleaned to remove residue each time bleaching powder is dissolved because it includes many impurities. −Dissolving tank is main facility in disinfection system and small numbers of mechanical and electrical equipment are included.
Safety	−No risks exist during storage since the raw material is salt. −The effective chlorine concentration of electrolytic sodium hypochlorite (produced) is low at about 1%, so handling is comparatively safe. −Although hydrogen is generated during production, safety circuit is provided in dilution fans in the production equipment to enhance safety.	−Must be sealed and stored in dry, dark and cool place. Care is necessary since chlorine may be released if acid reaction takes place. −Care is necessary since oxygen and chlorine may be released during thermal decomposition if a fire occurs. Decomposition occurs at once especially at temperatures above 150ºC; oxygen is released leading to risk of explosion.
Operating cost (150 kg-cl_2/day conversion)	Raw salt consumption = 525 kg/day Raw salt unit cost = 153 Kyat/kg Cost of chemicals= 80,325 Kyat/day Power consumption= 788.2 kW/day Power cost per unit= 100 Kyat/kWh Power cost = 77,820 Kyat/day Total = 158,145 Kyat/day (50%)	Raw salt consumption = 231kg/day Raw salt unit cost = 1,323 Kyat/kg Cost of chemicals = 305,613 Kyat/day Power consumption = 58.2 kW/day Power cost per unit = 100 Kyat/kWh Power cost = 8,520 Kyat/day Total = 314,133 Kyat/day (100%)

From the results of the comparative study above, electrolytic sodium hypochlorite (produced) will be used as the chlorine disinfectant considering the following points:

- Raw salt can be procured on site; therefore, procurement of chemicals from overseas is not

necessary

- Operating cost is low so economic burden is small
- The system installed in the No. 8 water treatment by MCDC using its own funds, is similar to the system used in the No. 4 water treatment plant constructed under the Japan's grassroots technical cooperation; therefore, operation and maintenance is consistent and beneficial.

In terms of supply condition of electricity in Mandalay city, there occurs blackout for short period: however, power supply interruption of long period is very few and the current electricity supply condition doesn't have any negative impact on the operation of sodium hypochlorite generation equipment.

The policy for procurement of sodium hypochlorite generation equipment, a vender having local agency that can correspond to repair in failure of equipment and supply spare parts shall be selected.

2－2－1－2. Policy on natural and environmental condition

(1) Policy on natural conditions

Based on the natural conditions in Mandalay city, the following items are considered at the time of design of facilities and equipment regarding water supply system.

Outside temperature (maximum)	: 50ºC
Outside temperature (minimum)	: 0ºC
Relative humidity	: 80-100 %
Average annual precipitation	: 900 mm

The rainy season in Mandalay City is for six months from May to October. The annual precipitation amount is about 900 mm, and this precipitation is rather small compared to other areas in Myanmar. The site for construction of a distribution reservoir has suitable soil structure condition and does not need a pile foundation. However, a proper construction plan must be considered accounting for construction works during appropriate period and ensuring that the ground surface does not get disturbed due to precipitation when working with direct foundation. The work of laying pipes will extend over a longer period, and the rainy season cannot be avoided. Therefore, drainage plan must be considered at relevant locations during excavation works. The pipes may have to be passed under existing wastewater gutters, so the work may have to be performed to avoid the existing gutters. The degrees of protection of dust control and drip-proof for mechanical and electrical equipment which gives consideration to high temperature and high humidity must be adopted.

(2) Policy on resisting earthquakes

Official seismic code equivalent to the Building Standards Act of Japan has not been enforced in Myanmar yet. MCDC has been referring to the Uniform Building Code of the USA (1977), and according to this code, the seismic zoning coefficient for Mandalay City is Z=0.3. This level is about the same as the level in Wakkanai and Fukuoka cities in Japan. This coefficient, however, differs in characteristics from the Z-value (0.7-0.8) in the Building Standards Act of Japan, but design of structures will be carried out conforming to the seismic code of the same area within Japan.

(3) Policy on socio-economic conditions

The poverty ratio in the target area of Pyi Gyi Tagon TS, in which distribution pipe network will be installed in the Project, is high. Therefore, a consideration is required for the poor people in the Project. The house connection will be carried out by the Japanese side for this reason along with the following reasons.

- Quality of water supply facilities must be ensured from the viewpoint of measures against non-revenue water.
- By giving guarantee of early completion of work, effects of the Project can be demonstrated quickly.

The number of house connections to be procured and installed by the Japanese side is assumed as the number confirmed at the time of the detail design stage. On the other hand, with regard to the remaining house connections to be installed from the detail design to the year 2020, the Japanese side takes responsibility for procurement of the materials for house connection and the Myanmar side takes responsibility for installation of these house connections.

The Myanmar side will be responsible for studying and setting connection charges considering the poor people, and for promoting house connections.

2－2－1－3. Policy on construction and procurement conditions

Materials and equipment that can be procured in Myanmar will be procured in Myanmar. Materials and equipment that cannot be procured in Myanmar or for which adequate quality cannot be ensured, will be procured from a third country or from Japan.

Presently, compliance standards for industrial products used on site are a mixture of different standards that vary according to the procurement source at Project site and include: International Organization for Standardization (ISO), British Standard (BS), American Society of Testing and Materials (ASTM) and Thai Industrial Standard (TIS). For this Project, the ISO standards were mainly studied considering quality controls, workability and O&M after construction using materials and equipment procured from a third country or Japan. If other international standards are to be used, then their compatibility with ISO standards will be considered.

To ensure continued operation and maintenance in future by the Myanmar side, the materials and equipment to be procured for this Project will be such that the Myanmar side can procure consumables or replacement parts of these materials and equipment from an agent of the supplier located in Myanmar.

The national communication corporation will give permission to MCDC for the use of communication network to be used for the monitoring system. Both sides (Myanmar and Japanese) will adequately study the interface of the monitoring and communication systems adjusted by the Japanese side and consider how best the systems data transmission on the Japanese side can be operated smoothly.

2－2－1－4. Policy on using local companies

Many infrastructure providers (companies) are working in Myanmar presently. There are many local companies with good track record in civil engineering and construction work, and technical skills have reached to a constant level. Local engineers and local skilled laborers also form part of the workforce in civil engineering and construction works. Accordingly, the use of local construction companies familiar with the working environment and social conditions on site as sub-contractors of Japanese companies implementing the Project will cut down costs and ensure smooth implementation of the work at the same time.

2－2－1－5. Policy on management, operation and maintenance

MCDC has the technical skills for maintenance of pumps and motors because of its experience in the past in overhauling such equipment; so there are no issues in O&M capability. Establishment of DMA of distribution pipelines and installation of monitoring system will be a first-time experience; therefore, instructions for using hardware and software and guidance on O&M will be necessary. The plan will be framed such that it supports MCDC through transfer of technology in the stages of adjustment and trial operation, including guidance through the soft component.

2－2－1－6. Policy of setting grades on facilities, materials and equipment

In principle, the operating and control procedures of the water supply system in Pyi Gyi Tagon TS will be consistent with those at the existing facilities considering the existing O&M techniques.

The Mandalay City power supply sometimes has unscheduled outage; so the operation of water supply facilities may be suspended. Outage occurred 79 times in 2014 (from Apr. to Dec.), which gives an average outage time of about 2.3 hours. According to MCDC, one emergency generator one submerged pump for well in BPS No. 7 is installed and one emergency generator for one distribution pump of BPS No. 1 is installed. However, since the power supply situation has been improving year after year, it was reported that the standby generator has not been operated in 2014. In this way, considering that in most existing facilities, no standby generator is provided, no emergency power

supply equipment will be provided so as to reduce the construction cost.

In short power outages, distribution pump will be stopped. However, disinfection facility is not stopped when water is being distributed as both disinfection and water distribution are stopped simultaneously when power is stopped. If an emergency generator is installed to respond to short-period outage, the operation and maintenance cost (fuel cost) for operating the generator increases: thus sustainability of waterworks operation is not ensured

Uninterrupted Power Supply (UPS) will be designed for monitoring system installed in DMA for distribution pipelines in the Pyi Gyi Tagon TS as a measure against power outages for short periods.

In the view of disaster prevention, policy on design of facilities and equipment is described below.

- Since it becomes large impact on waterworks due to leakage accident of main distribution pipeline which constitutes main pipeline of each DMA and distribution pipe to the planned served area, ductile iron pipe having high intensity and high impact resistance is used.
- Distribution network with high maintainability is planned to continue water supply in case of occurrence of any leakage accident. For example, loop pipeline alignment is planned in each DMA.
- In order to implement firefighting, fire hydrants are installed appropriately in the planned network.
- It is confirmed that flooding doesn't occur in the proposed area of intake wells; however, the floor level of intake well building in which electrical equipment for intake pump is installed is raised higher than the proposed ground level and it is planned to prevent damage by flooding in rainy season.
- Since the ground level in the proposed area for new distribution pump station is higher than the surrounding area, and although flooding damage doesn't occur, the floor level of new pump station is raised higher than the proposed ground floor considering unexpected flooding.

2－2－1－7. Policy on construction method/procurement method and construction period

To reduce the construction period, the types of construction work falling under the critical path method will be reduced. In particular, the total length for laying distribution pipelines including transmission and distribution pipelines is about 100 km. The work period can be reduced by increasing the number of teams employed in pipe-laying work.

Installation of house connections is also a factor affecting the construction period. The number of house connections for installation by the Japanese side is estimated based on the population served in 2015 (implementation year of detailed design of the Project). It is necessary for complete house connection that the number of teams will be increased for connection work, and MCDC activities to give explanations to the residents and public awareness campaigns through soft component must be carried out to promote house connection formalities by the residents.

Other measures include repairs to the store house in the existing pumping station building for disinfection facilities to be installed in the BPS No. 1, and repairs to existing pits in the chlorine storage facilities, so that the construction cost and construction period can be reduced.

Consideration of cost reduction and continuity of O&M on site will be taken as the basic principle; however, from the aspects of ensuring quality and reducing the life cycle cost, a third country or Japan will be considered for procurement countries for the following materials and equipment to be used in the Project as built-in equipment.

Materials/Equipment	Reason to include equipment into construction plan
Pump/Motor	Important equipment in this plan; the performance of existing product is poor, breakdowns are frequent and there is no agency to support after-sales services.
Monitoring system	Flow meters and water pressure gauges form part of the comprehensive monitoring system. If quality of monitored equipment and communications equipment is not ensured, the monitored data may be deficient. Therefore, equipment of good quality and good O&M capability must be selected.
Water meter	Chinese water meters are generally used in recent years in Mandalay City. However, many of these are broken. Japanese water meters are of good quality and are also easy to maintain. Since these water meters will become the basis for collection of water tariff, procurement from a third country or Japan where water meters have high quality and high maintainability will be selected.

2－2－2. Basic Plan (Construction Plan/Equipment Plan)

2－2－2－1. Construction Plan

(1) Scope of the Work

The components included in the scope of this cooperation Project are as given below.

Table 2-6 Summary of facilities to be implemented

No.	Components and Item	Quantity
A. Water supply system for Pyi Gyi Tagon TS		
1	Construction of intake well, DN300 mm×140 m	2 wells[9]
2	Construction of observation well, DN100 mm×133 m	1 well
3	Construction of intake pump house, installation of submersible pump, pipe, valve and electrical equipment	3 places
4	Laying transmission main (Ductile Cast Iron pipe : DN250 to 350 mm)	Approx. 2.8 km
5	Construction of reservoir tank (Q=3,024 m^3) , RC structure	1 reservoir
6	Construction of disinfection facility (Disinfection room and Hypo-chlorine dosing equipment)	1 comp. set
7	Construction of distribution pump station including disinfection room	1 station
8	Installation of distribution pump set, 4.8 m^3/min × 55 mH, including pipe, valve and electrical equipment	3 sets
9	Laying distribution pipe line, Ductile Cast iron:DN200 to 450 mm, PVC： DN100 to 150 mm, PE ：less than DN50 mm	Approx. 99 km
10	Connection of water service pipe and meter (water service equipment)	8,309 sets
11	Procurement of water service pipe and meter	643 sets
12	Installation of monitoring system (5 sets of pressure gauges and flow meters, 1 set for Central monitoring instrument)	1 set
B. Disinfection facility		
1	Installation of hypo-chlorine generating set	2 places
2	Installation of hypo-chlorine dosing equipment	9 places
3	Construction or renovation for dosing equipment room	8 places[*2]
C. Soft component		
1	Enhancement of distribution management skills	1 set
2	Enhancement of skills in public awareness and dissemination	
3	Enhancement of groundwater management skills	

(2) Standards and Codes

The facility design for the Project is based on the following standards and codes.

Pumps: ISO
Motors: IEC

[9] Totally 3 wells are set as intake wells including 1 well constructed during the preparatory survey.

Electric equipment and machinery:	IEC or equivalent standard
Pipe material:	ISO, JWWA, JIS or equivalent standard
Construction standard:	Complying with Japanese or international standards
Road pavement:	According to MCDC standards
Design criteria:	Guidelines on the Design of Water Supply Facilities (2012), the Japan Waterworks Association and the local conditions related to water supply systems

(3) Water supply plan for the Pyi Gyi Tagon TS

1) Planned population served

The population of the water supply target area in the Pyi Gyi Tagon TS is 46,781 persons as estimated from the documents of the Department of Water Supply and Sanitation of MCDC (Water Supply Plan for Pyi Gyi Tagon TS, February, 2014).

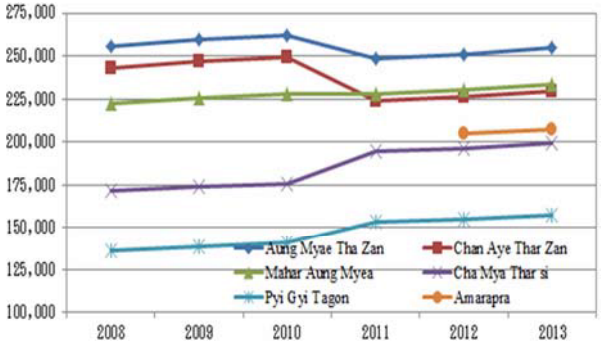


Figure 2-4 Trend of the population in Mandalay from the Year 2008 to 2013

2) Population growth rate

Documents giving population statistics in the past are from several sources - documents of the Ministry of Immigration and Population, General Administration Department, Mandalay District and the Department of Water Supply and Sanitation, and there are differences in the figures from each of these sources. Since the water supply plan has been formulated based on the documents of the Department of Water Supply and Sanitation, the population figures from this source is used in this Project to ensure consistency.

The graph showing the transition of population is divided into 3 Townships in the northern part (Aung Mye Thar San, Chan Aye Thar San, and Mahar Aung Myae), and 2 Townships in the southern Part (Chan Myar Tharzi and Pyi Gyi Tagon). The figure shows that the changes in population in 2010 and 2011 are significant and noticeable.

The population growth rate over a 6-year period from 2008 to 2013 in the northern and southern parts are -0.05% and 3.1% respectively. These figures account for the noticeable change in the population growth rate in 2010-2011. To estimate the population of the target area in 2020 and 2025, the values for which the range of change was very large were excluded and the average values are used. The results showed that the annual average population growth rate of the Chan Myar Tharzi TS and the Pyi Gyi Tagon TS in the southern Part was 1.5%.

According to the Department of Human Settlement and Housing Development, Ministry of Construction report on average annual population growth rate of Mandalay City ("Mandalay City Development Concept Plan Vision 2040") the estimated population growth rate of the city up to the next 30 years from 2011 is 1.01 to 2.1%. The estimated population growth rate (1.5%) in the past of

the two townships in the southern part lies within this range.

In view of the above, the annual population growth rate in 2020 and 2025, which are the planned target years of the Pyi Gyi Tagon TS, was taken as 1.5% based on the past average population growth rates (from 2008-2013).

Based on the above result, the population (P) trend up to year 2025 for two southern townships is estimated using the following formula.

$$P = P_1 \times (1+r)^n$$

Here,

P_1: Population in 2013
'r: Population growth rate
'n : year from 2013 up to 2020

Using the above formula, population in 2020 is estimated as follow;

$$P = 46781 \times (1+0.015)^7 = 51,919 \text{ (persons)}$$

For population data in 2020 and 2025 in the two southern townships reference is made to the following curve.

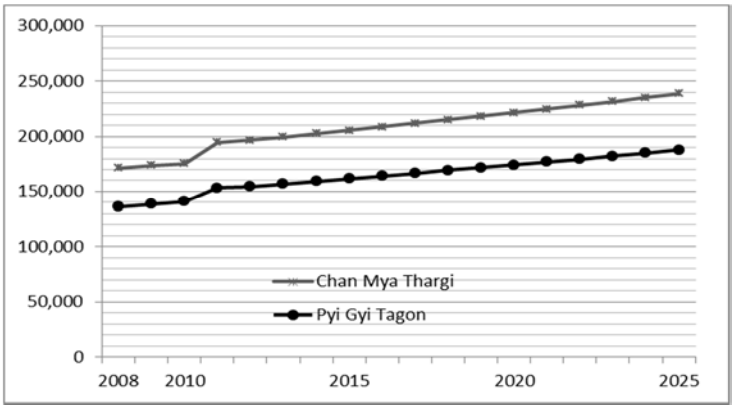


Figure 2-5 Population trend up to 2025 for two southern townships

Based on the population of 2013, the population served in the planned target areas (wards) in 2020 and 2025 are calculated and given in the table below.

Table 2-7 Population served in the target service area (Year 2020 and 2025)

Ward No.	Ward	Basic data			Future Population	
		Area (km^2)	No. of Block	Population In 2013	2020	2025
2-1	Thin Pan Kone	1.50	37	13,152	14,596	15,725
4	Ga	0.88	23	5,654	6,276	6,761
5	Ghagyi	0.42	18	12,057	13,382	14,415
6	Nga	0.56	11	3,393	3,765	4,056
10	Ngwe Taw Kyi Kone	2.52	31	12,524	13,900	14,975
Total of the target service area		5.88	120	46,780	51,919	55,932
Total of Pyi Gyi Tagon TS Area		30.31	857	157,062	174,314	187,786

Source of basic data: Dept. of Water and Sanitation, MCDC

3) Water demand

The various factors considered in the calculation of water demand are given in Table below.

Table 2-8 Various factors used in the calculation of water demand

Item	Calculation criteria
1.Domestic Use (Unit water demand (Lpcd))	Although the M/P Study implemented in 2003 considered the value of 180 Lpcd for the 2020 estimation, 130 Lpcd, which is the design figure for MCDC is used in this plan also. This is because; 1) According to the result of social conditions survey, the existing per capita consumption is 81-87 Lpcd and is relatively small. 2) The per capita demand of about 130 Lpcd is appropriate even if water consumption rate increase considering the improvement in water supply services.
2. Non-Domestic Use (Unit water demand (Lpcd))	Considered as 10% of water demand for domestic use. According to WASD of MCDC, the current percentage of domestic water use and non-domestic water use is 90 to 10% in southern 2 townships. This gives the percentage of non-domestic use to domestic use as 11%. External studies of existing served areas (wards) show that, these areas have large population of poor people hardly any hospitals and government agencies exist in these areas, shops and restaurants are few in number, primary school and market are at one location each. Therefore, 10% is an appropriate figure considering the developments of this area in the future.
3. Leakage	Considered as 10% of the daily average water flow rate The figure is likely to be below 10% since this is a new Project; however, the maximum value may be set as 10%.
4. Daily Maximum factor （1/Loading rate）	Considered as 1.1 times the daily average water flow rate About 1.1 is used in Yangon City, based on the “Preparatory Survey on the Project for the Improvement of Water Supply, Sewerage and Drainage System in Yangon City” in 2013. The same figure will be used for Mandalay City as well since the urban areas are similar to those of Yangon City. The loading rate is 0.9; variation in annual temperature is small; therefore, this figure is ideal for urban area.
5. Hourly Maximum factor	Considered as 1.5 times the daily maximum water flow rate Mandalay city has no design criteria on the hourly maximum factor. For reference, when the planned daily maximum water supply rate for this Project is plotted on the ”Graph on Hourly Average Water Distribution Rate and Hourly Factor in Residential Area” shown in “Design Criteria for Waterworks Facilities” by Japan Water Works Association, the hourly factor can be taken as 1.71. However, the dissemination rate of equipment using water such as washing machines, water heaters, etc. in Pyi Gyi Tagon TS is lower than the cities in Japan. In addition, since the difference between the daytime population and the night-time population in Pyi Gyi Tagon TS is small, water demand at the peak time doesn’t increase much and its variation is less than that in Japan. Therefore the hourly factor is considered to be less than 1.71. Accordingly it is judged appropriate to take the hourly factor as 1.5.

From the table above, the design water supply capacity is as given below.

Table 2-9 Design water flow

Description	Target Year (2020)	Target Year (2025)
Population served	51,919	55,932
Domestic water (m^3/d)	6,750	7,271
Non domestic water (m^3/d)	675	727
Leakage water (m^3/d)	825	889
Planned daily average water flow rate (m^3/d)	8,249	8,887
Planned daily maximum water flow rate (m^3/d)	9,074	9,776
Planned peak hourly water flow rate (m^3/d)	567	611

(4) Design of water supply facilities

1) Intake well

If the pump discharge from each well is set as 3,000 m^3/day approximately, the number of wells required to ensure the planned daily maximum water flow rate of 9,047 m^3/day is three. Already test boring of one well has been carried out during the preparatory study; this well will be used. Specifications for constructing a new well are given below.

2) Well structure

Estimating the geological structure	From the geology of the test bored well, geologic columnar section and results of electrical prospecting of existing wells, the distribution of the Third Layer (clay layer: confining layer) and the Fourth Layer (third aquifer), it was estimated that the new well excavation point was deeper than the test bored well boring point, and the assumptions below were made. Moreover, the thickness of the two layers mentioned above was assumed to be the same as that of the test-bored well. - Depth of upper surface of Third Layer (clay layer: confining layer): 80 m - Depth of lower surface of Third Layer (clay layer: confining layer)= Depth of upper surface of Fourth Layer (Third Aquifer): 100 m - Depth of lower surface of coarse-grained Fourth Layer (Third Aquifer): 125 m
Boring depth	Depth of lower surface of coarse-grained Fourth Layer (Third Aquifer) (125 m) + sand sump (two casing pipe lengths: 12.5 m) + over excavation (2.5 m) gives a total of 140 m.
Excavated hole diameter	About 420 mm (16.5 inches)
Well structure	Same as test-bored well in principle, but screen pipe will be Johnson-type among coil type, which has functions of wide water catchment area, low loss and high intensity.
Well borehole	300 mm (12 inches)
Casing pipe	SGP, 12 inches
Screen pipe	Installed in the coarse-grained part of the Fourth Layer (Third Aquifer), Johnson-type, ratio of whole area greater than 30%.

Well bottom	Bottom plug installed
Upper 2m	Cement grouting
2 m to Third Layer (confining layer) upper surface	Fill by drilling cut-fills, etc.
Third Layer (confining layer)	Sealing by bentonite (or clay)
Fourth Layer (Third Aquifer)	Gravel fill

3) Pump installation position

The drawdown reduction in groundwater level is estimated to be 17.65 m if water is assumed to be pumped out at the rate of the planned intake water (3,000 m^3/d).

Taking static water level (dry season) as 17 m, reduction in groundwater as 17.65 m, pumped water level and clearance of upper end of pump as 2.75 m, the total becomes 37.45 m. It is recommended to install the submersible pump at about 45 m after assigning a margin in the clearance at the upper end of pump and pumped water level (of about 5 m).

4) Submersible pump

Pump: Deep well submersible pump

Rate x head: 2.6 m^3/min. x 50 m, 3 no.

Motor: Low voltage 380 V, 3 phases

5) Monitoring well

The specifications of observation well structure for monitoring of level of groundwater are same as intake wells except for excavated diameter, well diameter and length of sand catching. The values of 3 items which are different from intake wells are mentioned below.

- Excavation diameter: Approx. 251mm
- Well diameter : Approx. 100mm
- Length of sand catching : Approx. 6m (1 casing pipe)

Pumping test for multiple wells will be implemented after construction of observation well and 2 intake wells.

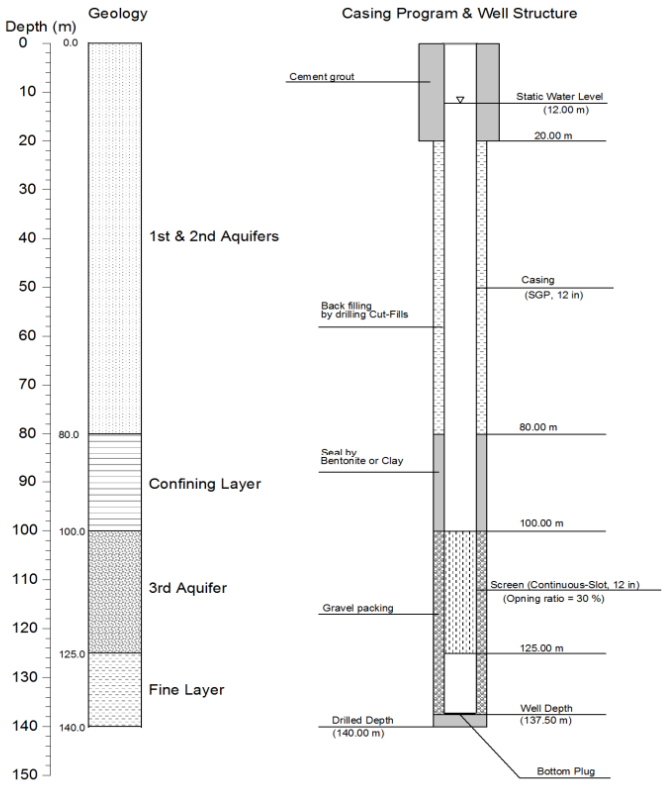


Figure 2-6 Structure of intake well

6) Distribution reservoir

The distribution reservoir is a facility to adjust daily water balance between the treated water flow rate and the distributed water flow supplied to the city. The use of water supplied to the city varies with time, with peak use in the mornings and evening. The planned capacity of distribution reservoir will be 8 hours of the planned daily maximum water flow rate; 6 hours for adjusting daily water fluctuation and 2 hours for fire-fighting and at the time of disaster.

Specifications of the distribution reservoir are given below.

- Distribution reservoir: 2 or more chambers, baffle wall, RC construction
- Influent and effluent valves: Manually operated
- Water level gauge: Pressure type

The required volume is calculated as shown below.

- Planned daily maximum water flow rate/3 (8 hours/24 hours) = 9,074 m^3/day /3 = 3,023 m^3.

Since the depth of supporting layer is 2.0m and sufficient bearing capacity of current ground is confirmed, base form of spread footing is adopted. The following shows the result of outline study for bearing capacity.

Load of distribution reservoir	:	Approximately 68,400 kN/m^2
Allowable bearing capacity for total area of distribution reservoir	:	Approximately 167,000 kN/m^2
Safety rate	:	Approximately 2.5

7) Distribution pumping station

a) Construction of distribution pumping station

The construction of the new distribution pumping station is proposed to be the same as that of the existing pumping station made of RC with one story below ground and one story above ground. Pumps and accessory pipe valves are to be installed in the story below ground, while electric instruments are to be placed in the story above ground.

b) Pump/motor

Pump type: Horizontal double suction volute pump

Flow rate x head: 4.8 m^3/min. x 55 m x 3 no. (including 1 stand-by)

Motor: Low voltage 380 V, 4 poles, 75 kW or less

The followings show calculation result of pump capacity.

The planned daily maximum water flow rate : 567m3/hour

Distribution flow rate per pump :4.725m^3/min ≒4.8m^3/min

Considering water pressure for supply of water to the first and second floor of building,

minimum dynamic water pressure at the end of distribution pipe network is set as 0.20MPa and hydraulic analysis is conducted. Subsequently, the head loss around pump equipment is considered and pump head is set.

c) Electrical equipment

As explained earlier, unscheduled power outages occur but their periods are becoming shorter. Therefore, measures against power outages are not required. The outline of electric equipment is given below.

- Because of the reason mentioned above, emergency power (generator) will not be included.
- All electrical equipment including low-voltage transformer will be installed in the pump room.
- Wiring after relay for the new transformer will be newly laid and supplied by the Japanese side.

d) Operation indicator

Operation display panel will include the following:

- Pump operation indicator
- Operation indicator for motorized valve at pump outlet
- Indicators for monitoring level of the treated water tank and interlocking of pump
- Flow rate and pressure monitoring indicators on the main pipeline on the pump discharge side
- Indicators for monitoring pump shaft bearing temperature and for interlocking
- Indicators for monitoring motor shaft bearing temperature and for interlocking
- Indicators for monitoring motor coil temperature and for interlocking

e) Pump water hammer measures

The topographic survey results show that the elevation within the distribution area is flat; therefore it is concluded that large scale water hammer effect will not occur. After preliminary analysis of water hammer by using pressure gradient line drawing, it is observed that the negative pressure with value of -10m occurs at 5 locations as shown in the figure below. However, since the degree of negative pressure is small and the elevation in the distribution area is flat with values ranging 70-75m, large counter pressure by vertical drop has not occurred; so large scale measures for water hammer are not required; instead air valves will be installed. The air valves to prevent water hammer are to be installed at 5 locations, where negative pressure occurs.

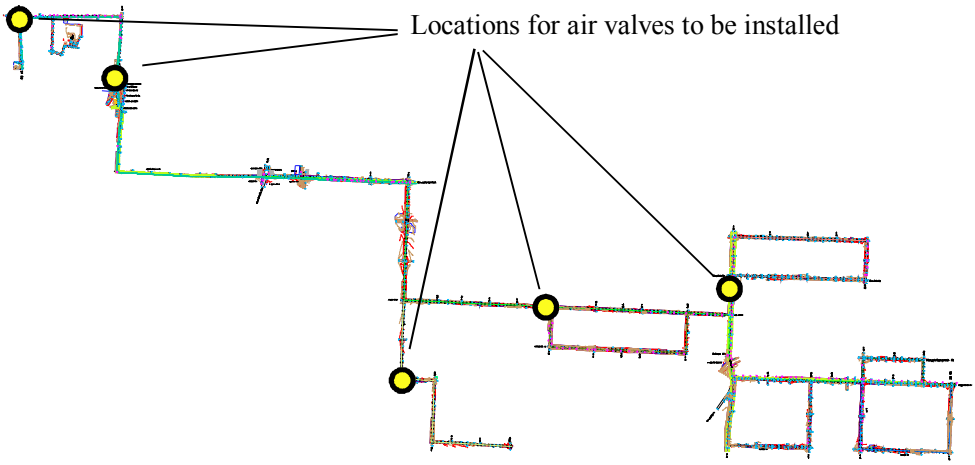


Figure 2-7 Location map for air valves to prevent water hammer in distribution pipelines

8) Laying transmission and distribution pipelines, and house connection

Materials of transmission and distribution pipelines, and house connection were classified by application and importance, and then selected according to their importance and workability. Applications and importance of the pipelines are given below.

Table 2-10 Applications and importance of pipelines

Type	Diameter	Application and importance
Transmission pipelines	250 to 350mm	These are raw water transmission pipelines for groundwater. These pipelines are very important because they ensure the planned intake flow rate to be obtained from 3 wells.
Distribution pipelines	200 to 450mm	These are pipelines that form the mains up to the target service area and distribution mains of each water distribution zone, and are highly important.
	150mm and 100mm	These are pipelines that branch out from the distribution mains as distribution secondary mains. Saddle ferrules for house connections are connected to distribution secondary mains. They are lower in importance than distribution mains.
	50mm	These are small distribution pipes that branch out from distribution secondary mains. Saddle ferrules for house connections are connected to small distribution pipes. They are lower in importance than distribution secondary mains.
House connections	13mm	These are house connections connected to distribution secondary mains and small distribution pipes through saddle ferrules. They are lower in importance than small distribution pipes.

The pipe materials selected after considering application and importance of pipelines are as given below.

a) Transmission and distribution mains (200 to 450mm)

Steel pipes and ductile cast iron pipes (DCIP) with superior durability and high strength are candidates for transmission mains for raw water and distribution mains that have high importance. For studying workability, non-destructive inspection of each joint is necessary after joining steel pipes by welding. On the other hand, ductile cast iron pipe has superior workability since the pipe has to be merely inserted into a rubber ring socket. The ductile cast iron pipe is economically more advantageous if the diameter is less than 450 mm. In view of the reasons above, the ductile cast iron pipe is selected.

According to the result of pipe thickness calculation by internal and external pressure for ductile iron pipe with diameter from 450mm to 200mm, it is confirmed that thickness of ductile iron pipe is satisfied with the required minimum pipe thickness.

b) Distribution secondary mains (100 to 150mm)

Rigid polyvinyl chloride (PVC) pipe, which is light and has excellent work efficiency, is selected for the distribution secondary main. The distribution secondary main has to pass under many underground obstacles, and moreover, curves with large bends will also be many; therefore, PVC pipes which enable easy connections by just inserting them into rubber ring sockets are superior to polyethylene pipes (PE). House connections can also be easily connected from distribution secondary mains using saddle ferrules.

According to the result of pipe thickness calculation by internal pressure for PVC pipe with diameter from 150mm to 100mm, it is confirmed that thickness of PVC pipe is satisfied with the required minimum pipe thickness. With regard to external pressure for PVC pipe, according to "Design Criteria for Japan Waterworks Facilities (JWWA: Japan Water Works Association)", in case that PVC pipe is laid in soil, there is no problem and study on pipe thickness is not needed in case of following conditions; 1) local load to PVC pipe by stone doesn't occur, 2) Pipe diameter is less than DN 300mm, 3) Earth covering is more than 60cm.

c) Small distribution pipes and house connections

PE pipes, which are light in weight and similar to PVC pipes with excellent working efficiency, are selected for small distribution pipes and house connections. Bends need not be used at gradual curved parts with corners since the diameter is small; the pipe can be laid making use of its inherent flexibility. Although fusion connections have a high tendency of workmanship defects, if small diameter pipes are used, screw connections can be appropriately implemented; therefore PE is selected.

With regard to internal pressure for PE pipe, safety rate of 2.0 is secured when design internal water pressure is 1.0MPa. For external pressure for PE pipe, according to the experimental result of "Survey Report on PE pipe and joint for water supply (JWWA)", it is described that flexure/fracture of PE pipe due to earth load and water pressure is smaller than that with only water pressure; therefore, the required PE pipe thickness has already been secured and pipe thickness calculation is not required.

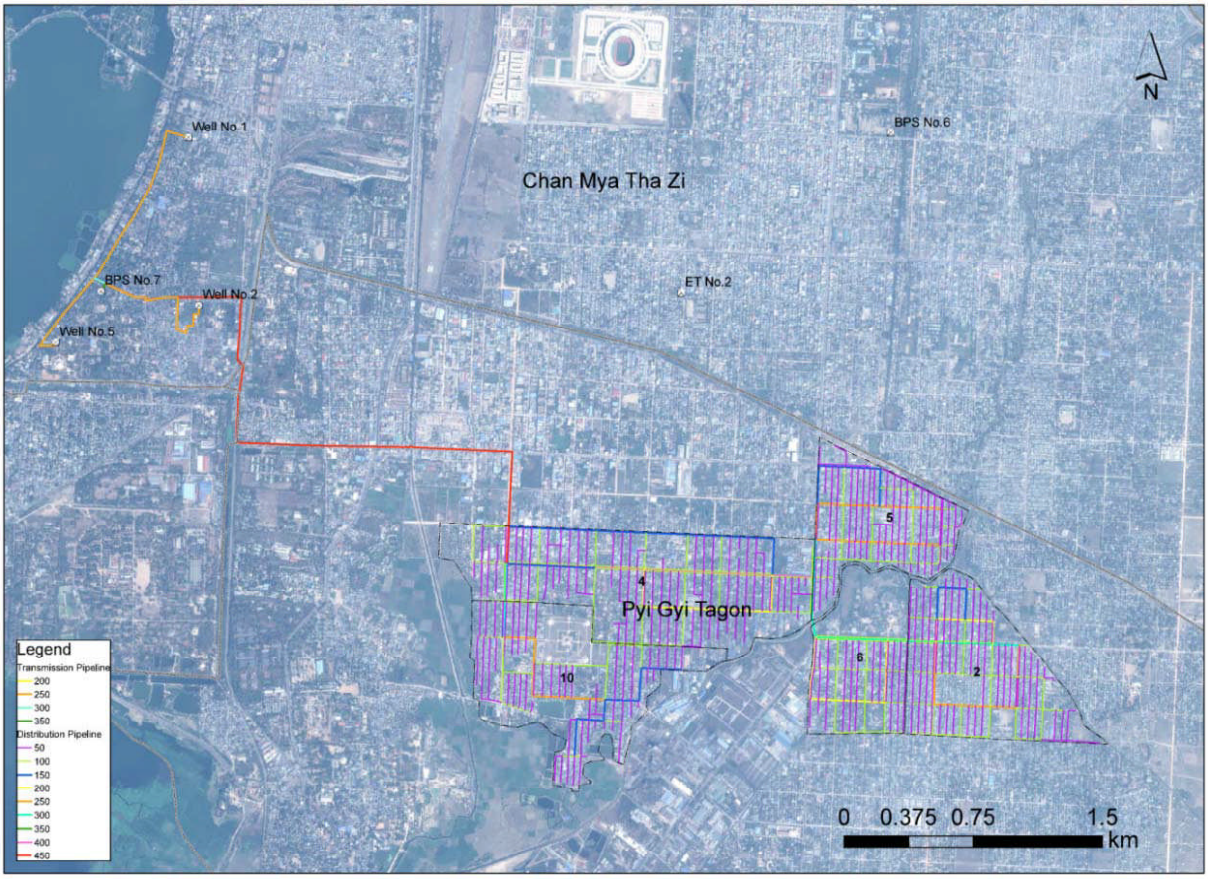


Figure 2-8 Planned pipeline route in Pyi Gyi Tagon TS

d) Length of transmission and distribution mains

The planned pipeline route is shown in Figure 2-8. The length of raw water mains and distribution pipelines is about 2.8 km and 98.5 km respectively. The table below shows the pipe material by diameter and the approximate length.

Table 2-11 Transmission pipe length and material

Diameter (DN, mm)	Length (m)	Material
350	100	DCIP
300	100	DCIP
250	2,600	DCIP
Total	2,800	

Table 2-12 Distribution pipe length and material

Dia.(mm)	Length (m)	Material
450	4,000	DCIP
400	1,800	DCIP
350	0	DCIP
300	2,200	DCIP
250	4,000	DCIP
200	2,900	DCIP
150	4,800	PVC
100	24,200	PVC
50	54,600	PE
Total	98,500	

DCIP: Ductile Cast Iron Pipe, PVC: Polyvinyl Chloride Pipe, PE: Polyethylene Pipe

e) Pipe bridge

Steel pipe is selected as pipe bridge since it easily gives continuity of strength to the entire water pipe. The number of locations to install pipe bridge is 3 as mentioned below. Out of 3, 1 location has a stiffening trusses type of inverted triangle.

Pipe bridge 1: 450mm, L=10.0m, pipe beam type of simple support

Pipe bridge 2: 450mm, L=14.0m, pipe beam type of simple support

Pipe bridge 3: 300mm, L=33.0m, stiffening trusses type of inverted triangle

f) Pipe crossing under railway and drainage canals

- Select pipe jacking method. Adopt the method of inserting distribution pipe into casing pipe.
- Select open cut method for distribution pipe to pass under small scale drainage canal.

g) Typical cross section of excavation and pavement

The following drawings show typical cross section of excavation and pavement. The method of pavement follows the specifications defined by the Department of Road, MCDC. It needs to use asphalt pavement on main road. Since the layer and thickness of each layer is different depending on construction year of each road, the pavement method is considered based on current condition. Most of branched road from main road is non-pavement road; however, there is some road with base course. Furthermore, there is concrete road and it is necessary to follow the specifications of Department of Water and Sanitation, MCDC in case of the layer of concrete pavement.

Distribution pipe is planned to install along the road shoulder; however, if road shoulder doesn't exist and pipe is installed under the road, restoration work of pavement is necessary. Earth covering of transmission and distribution pipelines is from 1.0m to 1.2m. Distribution pipelines with length of 30m cross the main road namely Yangon- Mandalay Road and it is necessary to conduct temporary and permanent restoration work.

The existing pipelines were installed near BPS No.7. The Contractor shall conduct trial excavation before the construction work for prevention of damage to the existing pipelines. Outline of planned pipelines route and location of pipe laying work have already been reported to the Department of Road, MCDC.

Figure 3-9 and 3-10 are MCDC's standard drawings "Standard Excavation Section Drawing and Standard Pavement Section Drawing (1) & (2) on Laying Pipeline". The detail design on laying the pipeline is made based on these standard drawings taking into account the local conditions.

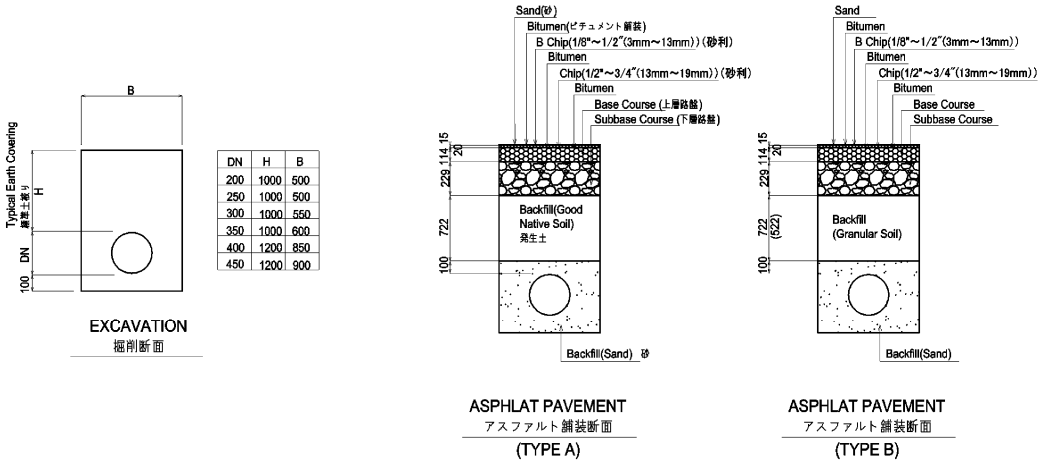


Figure 2-9 Typical cross section of excavation and pavement (1) (Department of Road, MCDC)

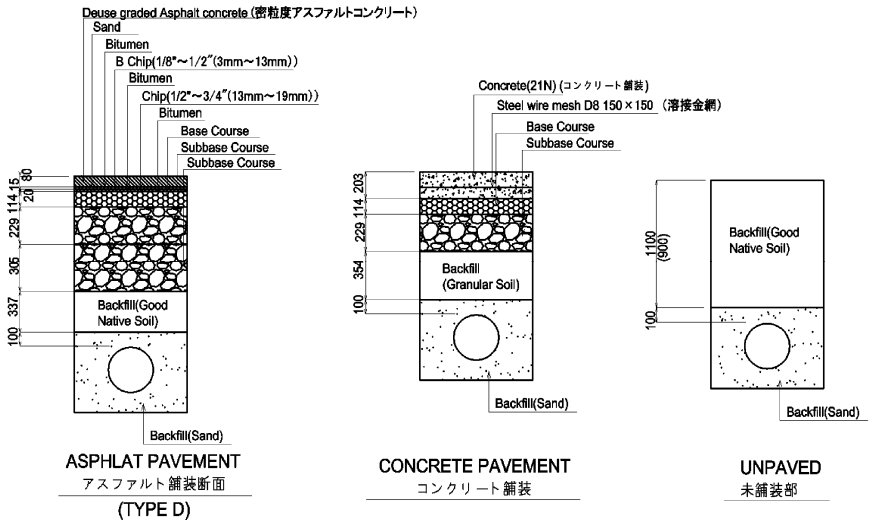


Figure 2-10 Typical cross section of excavation and pavement (2) (Department of Road, MCDC)

h) Others

- To install air valves, drain valves and sluice valves appropriately, based on configuration of the terrain configuration and distribution pipes.
- Install fire hydrants in the distribution mains (bore greater than 150 mm) in the target service areas

9) House connections and water meters

a) Scope of the Project related to water service equipment (service pipes and water meters)

Two types of scope have been set for procurement and construction (pipe laying work) of water service equipment (house connection pipes and water meters) in the Project. These are included in the scope of the Japanese grant aid program and their definitions are given below.

Table 2-13 Scope of water service equipment and definitions of number

No.	Scope of the Project	Definition of number
1	Procurement and pipe laying work for water service equipment (water service pipe and water meter, etc.) as part of Construction Plan	The number of house connections for pipe-laying work and procurement of materials and equipment by grant aid cooperation scheme The number of house connections will be determined from the result of field survey in the detail design stage (assumed in 2015), information on registration record of residents, and confirmed number of required house connection and willingness to connect.
2	Procurement of water service equipment as part of Equipment Plan	The number of house connections for pipe-laying work by the Myanmar side after procurement of materials and equipment by grant aid cooperation scheme The number of house connections will be estimated by deducting the number in No.1 above from the estimated number of households in the target year 2020.

As shown in No.1 in the table above, procurement and pipe laying work for water service equipment (water service pipe and water meter, etc.) are implemented as part of Construction Plan. The procurement work of water service equipment as part of Equipment Plan in No.2 in the table above, is described in "2-2-2-2 Equipment Plan."

The number of water service equipment procured as part of the Construction Plan in Table 2-13 above and the number of house connections to be implemented in the pipe laying work are estimated as below.

1) Population in the target service area in 2015 when detailed design will be implemented: 48,195 persons
2) No. of persons per household: 5.8
3) No. of households in the target service area (1)/2)): 8,309 households

Source: 1) JICA Study Team calculated value 2) Survey results of social conditions

If the number of house connections for pipe laying and procurement of materials and equipment is defined as one per household according to the grant aid cooperation, it can be calculated as 8,309. Later on, the number of house connections will be finally decided by using and reviewing the result of field survey during the detail design stage (assuming in 2015), information on registration record of residents stored in the MCDC Township office of the Pyi Gyi Tagon TS that administer the target service area, confirmed number of requirement of house connection, and willingness to connect.

The scope of water service equipment for pipe laying work and procurement of materials and equipment by the grant aid cooperation, and the boundaries of the Japanese and the Myanmar sides are shown in the figure below. Water service pipes and water meters that have branched out from distribution secondary mains and small distribution pipes fall under the scope of procurement of materials and equipment and pipe laying work of the Japanese side; while the part from the secondary

side of the water meter to the water tap falls in the scope or procurement of materials and equipment and pipe laying work of the Myanmar side.

MCDC has the ownership rights to water service pipes and water meters. The ownership rights from the secondary side of the water meters to the water tap lie in the residents; the expenditure will be borne by the residents for this part.

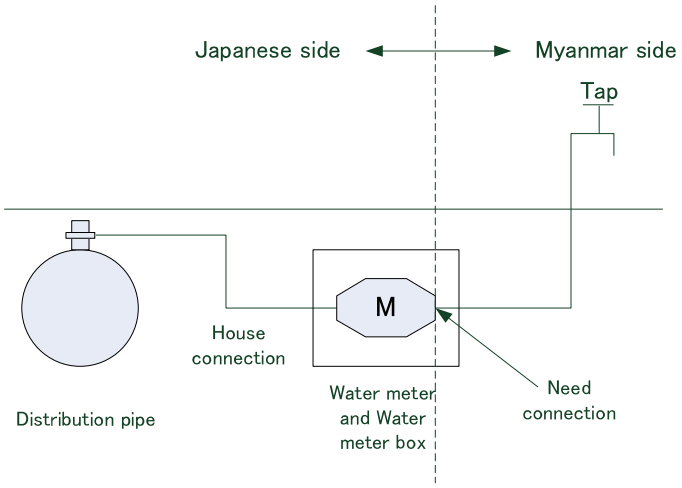


Figure 2-11 Scope of work related to house connection equipment to be borne by the Japanese side and the Myanmar side

The table below shows the details of materials and equipment for house connections. To respond to changes in topography and to avoid underground obstacles, PE pipes with light weight and good workability will be used as house connection pipes. At locations with sharp bends, elbows will be used. In principle, sand and good soil will be used for backfilling during pipe laying work so that the pipe body is not scratched or damaged in any way. Straight stop valves will be installed for operation and maintenance of water meters. Water meters will be enclosed in water meter boxes so that they can avoid damage and retain their functions adequately. In principle, water meter will be installed within the premises of each household (near the entrance).

Table 2-14 Details of house connection equipment

Name	Specifications
Saddle	DN 50 mm ×13 mm, made of cast iron
Service pipe	DN 13 mm, PE pipe, L=5.5m (including elbow and socket)
Stop valve	13 mm stop valve with non-return valve
Water meter	13 mm direct reading type with strainer
Water meter box	For 13 mm

b) Water meter

The standards of the Japanese Measurement Law and standards equivalent to R-100 apply to

the accuracy of meters to be used in this plan, as the intermediate class accuracy used in Japan. Quality assurance must be correctly performed since accuracy of the water meter influences the revenue from water tariff. For this purpose, the procurement of water meter from Japan or a third country such as a country belonging to the Organization for Economic Cooperation and Development (OECD) may be studied.

c) Cost to be borne by residents for water supply connection

Based on the discussions between the JICA Study Team and the MCDC, it was agreed to levy only the registration fee of 100 Kyats/household for the 8,309 connections that fall under 1 (Procurement and pipe laying work for water service equipment as part of Construction Plan) in Table 2-13. For connections that fall under 2 (Procurement of water service equipment as part of Equipment Plan), it was agreed to levy construction costs, connection permission fees, connection fees to distribution mains, and prior survey fees excluding registration fees and material expenses procured by the Japanese side.

10) District Metering Area (DMA) and remote monitoring system

a) Setting of DMA

In order to achieve the following purposes, DMA will be set.

① To implement distribution management in a normal supply condition

② To enable taking adequate and fast response in case of emergency such as water leakage and occurrence of disaster event

In a normal supply condition, stable water supply is secured through monitoring of distribution water in flow rate and pressure. By clearly understanding of the valve locations in DMA, effect of water leakage can be minimized and repair period can be shortened. For these purposes, DMA shall be set.

The following factors are generally taken into consideration for setting of DMA.

i) Dividing of target service area into high area and low area by altitude

ii) Dividing of target service area by topography (River and road)

iii) Dividing of target service area by land use

iv) Number of house connections per DMA (500~3,000 connections) shall be the optimum number adopted by IWA (International Water Association)

Since topography of the target service area is flat with range 70m to 75m and residential area covers whole target service area, the factors of i) and iii) above are not applicable; therefore, delineation DMA boundaries are considered by the factors of ii) and iv) above.

As a result of the study, it is judged that ward boundary of administrative unit for MCDC is desirable condition to divide the target service area as shown below and five (5) DMAs are set.

Estimation of number of house connections in this case is shown below, it ranges from 500 to 3,000 connections; therefore, it is judged that scale of each DMA is appropriate.

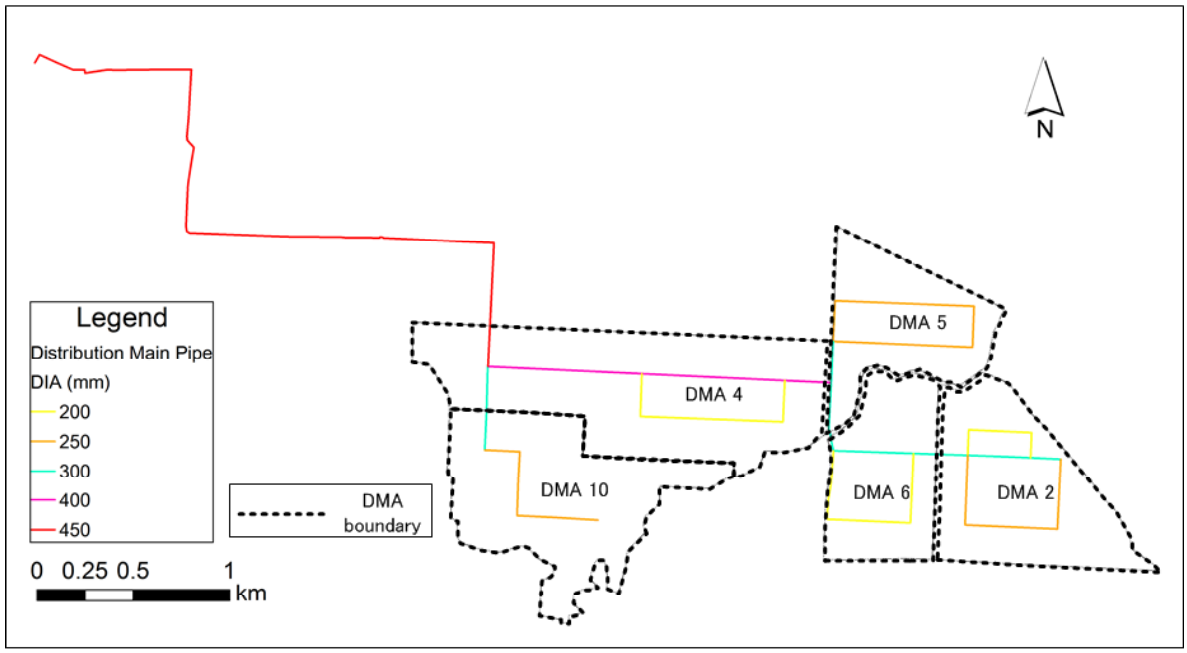


Figure 2-12 Result of DMA setting

Table 2-15 Estimated number of house connections for each DMA

DMA No.	Population served in 2020	Number of house connections in 2020
2	14,596	2,517
4	6,276	1,082
5	13,382	2,307
6	3,765	649
10	13,900	2,397
Total	51,919	8,952

b) Remote monitoring system

DMA will be set for appropriately controlling distributed water volume and pressure in the distribution pipeline network of this plan. DMA boundaries will be set similar to the five administrative districts (No. 2, 4, 5, 6, and 10) included in the planned target area. Data from flow meters and water pressure gauges, which are monitoring equipment to be installed in the inlet mains of each DMA will be transmitted to the center, where such data will be monitored after collection and analysis. In addition, these data collected and analyzed data will be compared with the water flow observed at the outlet of No.7 pump station and non-revenue water will be calculated. The required equipment at each site and the center, for this purpose, is as given below.

<Main Control Center (MCC)>

- SCADA Server
- SCADA HMI

- Monitor
- Printer
- UPS
- Monitor table and chair
- Router
- Server Rack

<DMA (at the inlet of DMA)>

- Flow meter and Transmitter
- Water pressure gauges and pressure transmitter
- UPS
- Interface panel
- PLC
- Router

*Pressure gauges and flow meters installed in distribution pump station are included in the scope of distribution pump equipment.

When a wired system is used as the communication system for the monitoring system, an application to the authorization concerned is complicated. In addition, the operation and maintenance cost of it such as communication charges, etc. is higher than in a wireless system. The mobile telephone system is developed at the urban area in Myanmar, and the GPRS (General Packet Radio Service) system, which has the high speed transmission is adopted in the most popular mobile telephone network, and also used for the SCADA (Supervisory Control And Data Acquisition) system. Meanwhile, the communication speed of wireless systems such as GSM (Global System for Mobile Communications), is lower than GPRS and its communication charge is higher than that of GPRS to make communication by conversion from voice to digital signal. Accordingly, GSM has no advantages as a communication system of SCADA for this Project.

Uninterruptible power supply (UPS) system will be installed to operate equipment in the event of a power outages. Continuous operating time during outages will be about 120 minutes; this system is adequate to cope with short-period outages. However, in case of long-period outages, data acquisition will be disabled regardless of water being distributed continuously from the distribution reservoir by gravity. This missing data will be compensated by using the data for the same time zone during normal working hours, and the distribution amount will be estimated.

The location map of equipment for monitoring system is shown below.

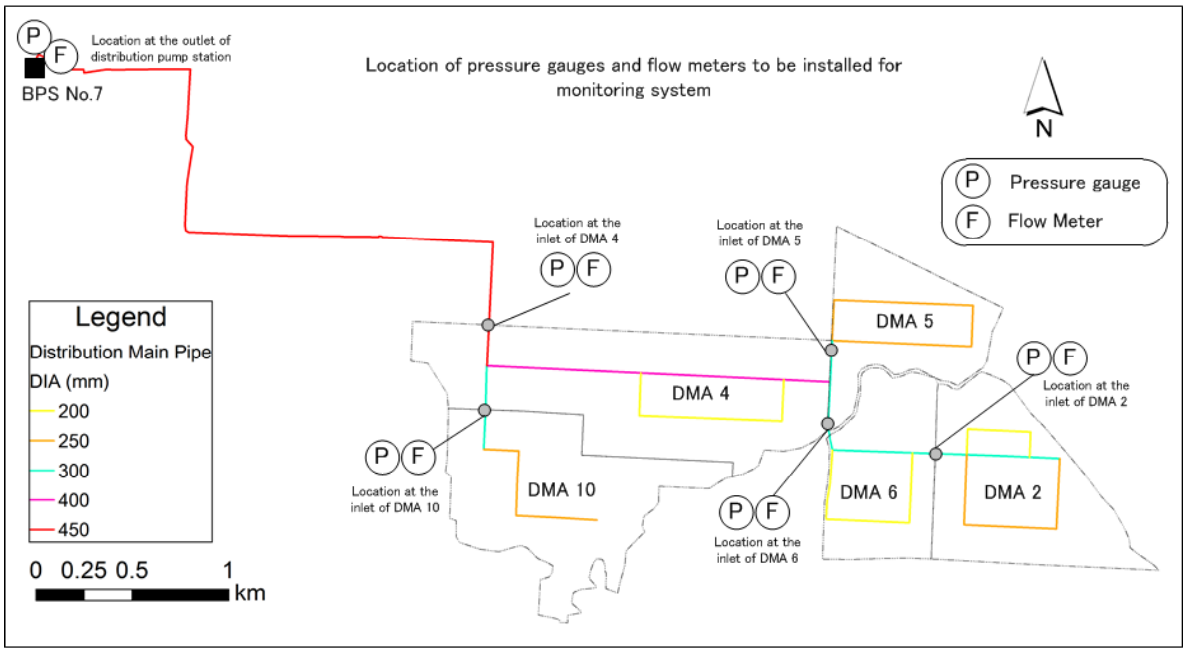


Figure 2-13 Location map of pressure gauges and flow meters to be installed in monitoring system

(5) Design of disinfection facilities

1) Setting the chlorine dosing rate

To set the chlorine dosing rate, the chlorine demand was estimated by experiments using raw water at each of the main facilities in the water supply system and by calculating the theoretical chlorine demand. The theoretical chlorine demand was also calculated by the chlorine consumption properties (organics, iron, manganese, ammonia nitrogen, ammonia nitrogen compounds, etc.) from the results of water quality analysis at each supply point. The experimental chlorine demand and the theoretical chlorine demand from experiments at each of the main facilities in the water supply system are summarized below.

Sampling point (Dosing point)	Experimental value ($mg\text{-}Cl_2/L$)	Theoretical value ($mg\text{-}Cl_2/L$)
BPS No.1	0.263	0.293
BPS No.2	0.335	0.332
BPS No.3	0.129	0.205
BPS No.5	0.410	0.288
BPS No.6	0.304	0.217
BPS No.7	0.369	0.192
Well No.28	0.333	0.319
ET No.1	0.296	0.179
ET No.2	0.201	0.103

From the results above, the chlorine demand of each of the main facilities in the water supply

system is below 0.5mg-Cl_2/L; however, considering for seasonable variation and water quality variation the chlorine demand is taken as 0.5mg-Cl_2/L. Since ground water has good quality and chlorine demand is lower than 0.5mg-Cl_2/L, the minimum value to be assured is set as 0.5mg-Cl_2/L.

Presently, there are no regulations for residual chlorine concentration in the Water Quality Standards of Myanmar. On the other hand, the WHO Drinking Water Quality Guideline recommends retaining the free available chlorine at above 0.5 mg-Cl_2/L in thirty minutes after chlorination. Upon discussions with the MCDC, the target for retaining free available chlorine is considered as 0.5mg-Cl_2/L or more in the distribution pipelines after dosing chlorine, considering the WHO Guideline as standards for this plan.

In view of the above explanation, the average dosing rate in this plan is set as 1.0 to 1.5 mg-Cl_2/L. The maximum dosing rate is set as 2.0 mg-Cl_2/L. However, the concentration of residual chlorine in the pipelines at any time varies according to the raw water quality, water temperature, effective retention time and conditions in the distribution pipeline network. Therefore, monitoring the residual chlorine concentration in the distribution pipeline network through daily operational management and optimizing the chlorine dosing rate are necessary for the actual operational management of the chlorine dosing rate.

Based on the above discussion, maximum dosing capacity of 1% sodium hypochlorite is calculated and given in the following table.

Table 2-16 Calculation of maximum dosing capacity of 1% hypochlorite

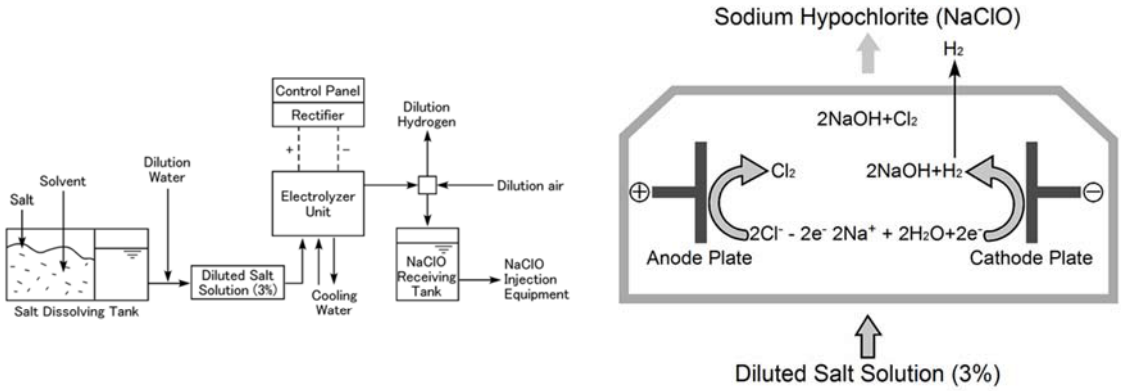
Dosing point	Design water flow (m^3/d)	Max. dosing capacity	
		Cl_2 (kg/d)	1% hypochlorite (m^3/d)
BPS No.1	106,450	212.9	21.9
BPS No.2	6,372	12.7	1.27
BPS No.3	2,400	4.8	0.48
BPS No.5	431	0.9	0.09
BPS No.6	2,139	4.3	0.43
BPS No.7 (existing)	3.525	7.1	0.71
BPS No.7 (New)	9,080	18.2	1.82
No.28 well	5,069	10.1	1.01
No.1 Elevated Tank	827	1.7	0.17
No.2 Elevated Tank	1,170	2.3	0.23

2) Sodium hypochlorite generation system

Sodium hypochlorite generation systems may be broadly divided into diaphragm process and non-diaphragm process. Since the volume handled in the Project is small, the non-diaphragm process which is advantageous for operation and maintenance of small scale system will be used.

Principle of non-diaphragm process

Raw salt (NaCl) is fed into the salt dissolving tank, dissolved it and saturated salt solution is prepared. Saturated salt solution is diluted to about 3% and supplied to the electrolyzing tank. Anodic and cathodic plates are installed in the electrolyzing tank; since the tank is of the non-diaphragm type, there is no diaphragm between the two electrodes. The supplied salt solution is electrolytically decomposed, and chlorine (Cl_2) is generated at the anode and hydrogen (H_2) at the cathode, and hydroxyl (OH) ions are formed. On the cathode side, caustic soda (NaOH) is generated with the sodium ions (Na^+) and (OH^-) ions, while at the anode, the caustic soda formed at the cathode reacts with chlorine (Cl_2) formed at the anode and sodium hypochlorite (NaClO) is produced. The process flow chart is shown below.



3) Production of sodium hypochlorite (produced)

The production points of sodium hypochlorite shall be at BPS No. 1 and BPS No. 7 considering the chlorine dosing volume, operation and maintenance system, number of employees and space for installing equipment at each production point. The total volume of sodium hypochlorite solution produced at each pumping station will be taken as the volume used at BPS No. 1. On the other hand, the sodium hypochlorite solution produced at BPS No. 7 is planned to be transferred in containers and used at the seven main facilities in the water supply system (BPS No. 2, No. 3, No. 5 and No. 6, No. 28 well, ET No. 1 and 2), in addition to being used at BPS No. 7.

The capacity of the sodium hypochlorite generation system will satisfy the daily maximum dosing amount. The system will be designed including allowance of 20% considering seasonal variations in water supply volume, rate of operation, etc.

The storage capacity of sodium hypochlorite at BPS No. 1 and 7, which are proposed as the production points for the same, is taken as the average dosing amount required for at least one day, considering replacement of electrodes, cleaning, and so on. Several storage tanks will be used for storing sodium hypochlorite, out of which one will be used as spare. On the other hand, the storage capacity of sodium hypochlorite container at the main facilities in the water supply system used to transfer the sodium hypochlorite produced at the production point is taken as 7 days x the average dosing amount considering the frequency of carrying the sodium hypochlorite. The capacity of the

sodium hypochlorite container is taken as 1 m^3, and one container will be used as spare at each of the main facilities in the water supply system for carriage or replacement of sodium hypochlorite.

The amount of chlorine generated in BPS No. 1 and BPS No. 7 is shown in the table below.

Table 2-17 Chlorine generated capacity

BPS No	Inflow to reservoir (m^3/d)	Max. dosing rate (mg/L)	Chlorine capacity (kg/d)	Generated capacity* (kg/d)	1% Sodium hypochlorite (m^3/d)
1	106,450	2	212.9	260	26
7	30,193	2	62.1	75	7.5

*: Generated capacity has an allowance of 20% of the required capacity

4) Sodium hypochlorite dosing point

The chlorine dosing point varies depending on the distribution system. In the Project, dosing in the distribution reservoir and elevated water tank at the main facilities in the water supply system or dosing into the distribution main on the distribution pump discharge side in the water supply system may be considered. In this plan, after considering the points listed below, dosing is proposed to be executed at distribution main on the distribution pump discharge side at each of the main facilities in the water supply system at 7 pumping locations (BPS No. 1, No. 2, No. 3, No. 5, No. 6 and No. 7, and No. 28 well). On the other hand, water is supplied by gravity flow at elevated water tanks at two locations (No. 1 and No. 2 elevated water tank); therefore, dosing will be in the elevated water tanks at these two locations.

- Since water temperature is high, drop in the residual chlorine concentration due to vaporization of chlorine in the long retention time in the distribution reservoir is a cause for concern.
- Concrete in the existing distribution reservoir is not made by corrosion-preventing measures; therefore, erosion of the concrete due to chlorine is a cause for concern.
- The existing distribution reservoir has a steel roof; erosion due to vaporized chlorine is a cause for concern.
- Start/stop of chlorine dosing can be carried out in conjunction with pump operation
- When dosing chlorine into the distribution reservoir, it should be done in proportion to the change of inflow of raw water to the distribution reservoir. Therefore, non-dosing and excess dosing of chlorine are cause for concern.

Chlorine is to be dosed into the distribution mains on the discharge side of the distribution pump at the seven water supply points so as to match the operation of the distribution pump. Since the distribution pump is manually operated, the chlorine dosing pump should similarly be manually operated to start and stop so as to match the start and stop simultaneously with the distribution pump. The adjustment of dosed amount is to be done manually by stroke control. On the other hand, chlorine is to be dosed into the elevated water tanks at two locations so as to match the intake volume of the

well pump because the well is a water source of the elevated tank in the same site. The dosing amount is to be adjusted based on the operating time of the dosing pump. Storage tank and container for sodium hypochlorite (produced) will be designed considering the design conditions below.

- Average inflow rate of distribution water: refer to the following table
- Average chlorine dosing rate: 1.5mg/L

Table 2-18 Dosing rate of sodium hypochlorite

Dosing point	Average inflow to reservoir (m^3/d)	Ave. dosing capacity (as -Cl_2Kg/d)	Ave. dosing capacity (as 1% sodium hypochlorite-m^3/d)
BPS No.1	106,450	159.7	15.97
BPS No.2	6,372	9.6	0.96
BPS No.3	2,400	3.7	0.36
BPS No.5	431	0.6	0.06
BPS No.6	2,139	3.2	0.32
BPS No.7 (Existing)	3,525	5.3	0.53
BPS No.7 (New)	8,260	12.4	1.24
Well No.28	5,069	7.6	0.76
ET No.1	827	1.2	0.12
ET No.2	1,170	1.8	0.18

The dosing pump will have the capacity that enables continuous dosing of maximum hourly dosing amount. Spare pump will be installed at each dosing point. During dosing into the distribution main on the pump discharge side, planned peak hourly water flow rate will be set based on the number and capacity of distribution pumps in operation because dosing is made for instantaneous flow rate of distribution water. On the other hand, during dosing into an elevated water tank, the planned peak hourly water flow rate will be set based on the distribution time because the distribution amount is adjusted by manually closing/opening the valve. The maximum hourly dosing amount at each of the main facilities is calculated from the planned peak hourly water flow rate and the maximum dosing rate at each of the main facilities. The table below gives a summary of the maximum hourly dosing amount of sodium hypochlorite solution at each of the main facilities in the water supply system.

Table 2-19 Sodium hypochlorite dosing calculation for dosing pump

Dosing point	Design hourly max. water flow (m^3/hr.)	Max. chlorine dosing rate (as -Cl_2.kg /hr.)	Max. 1% hypochlorite design rate(L/min.)
BPS No.1	9,720	19.44	32.40
BPS No.2	1,502	3.00	5.00
BPS No.3	450	0.90	1.50
BPS No.5	186	0.37	0.62
BPS No.6	320	0.64	1.07
BPS No.7 (Existing)	542	1.08	1.81
BPS No.7 (New)	568	1.14	1.89
Well No.28	480	0.96	1.60
ET No.1	414	0.83	1.38
ET No.2	293	0.59	0.98

5) Outlines of designs

- Hypochlorite generation equipment will be designed based on the capacity for daily maximum dosing amount
- Chlorine dosing points will be at the distribution mains on the distribution pump discharge side at pumping stations (BPS No. 1, No. 2, No. 3, No. 5, No. 6, and No. 7) and well group (No. 28 well), and in the two elevated water tanks (ET No. 1, No. 2).
- All operations of the dosing pump including start and stop will be manually carried out; adjustments of dosing capacity will also be done manually.
- The storage amount of sodium hypochlorite container at the main facilities in the water supply system (BPS No. 2, No. 3, No. 5, No. 6, No. 28 well, ET No. 1 and No. 2) other than the generation points of sodium hypochlorite (produced) will have an average dosing capacity greater than the amount required for 7 days, considering the carrying frequency.
- The storage capacity of sodium hypochlorite tank at the generation points (BPS No. 1 and No. 7) of sodium hypochlorite (produced) will be more than the average dosing amount required for one day.
- The dosing pump will have a capacity that enables dosing of maximum hourly dosing amount, and a spare dosing pump will be installed.

(6) Specifications of equipment in disinfection facilities

1) Disinfection facility in BPS No.1

a) Specifications of storage tank for sodium hypochlorite (produced)

Description	Specification
Type	Vertical type polyethylene tank
Content	1% sodium hypochlorite
Effective capacity	6 m^3
Quantity (Q'ty)	4 sets (1 set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	16.2 L/min.
Q'ty	3 sets (1set of stand-by)

c) Specifications of transfer pump for sodium hypochlorite (produced)

Description	Specification
Type	Magnet type dosing pump
Content	1% sodium hypochlorite
Discharge capacity	250 L/min.
Q'ty	2 sets (1set of stand-by)

2) Disinfection facility in BPS No.2

a) Specifications of storage container for sodium hypochlorite (produced)

Description	Specification
Type	For solution container
Content	1% sodium hypochlorite
Effective capacity	$1m^3$
Q'ty	8 sets (1set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypo-chlorite
Discharge capacity	5.0 L/min.
Q'ty	2 sets (1set of stand-by)

3) Disinfection facility in BPS No.3

a) Specifications of storage container for sodium hypochlorite (produced)

Description	Specification
Type	For solution container
Content	1% sodium hypochlorite
Effective capacity	$1m^3$
Q'ty	4 sets (1set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	1.5 L/min.
Q'ty	2 sets (1set of stand-by)

4) Disinfection facility in BPS No.5

a) Specifications of storage container for sodium hypochlorite (produced)

Description	Specification
Type	For solution container
Content	1% sodium hypochlorite
Effective capacity	$1m^3$
Q'ty	2 sets (1set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	0.7 L/min.
Q'ty	2 sets (1set of stand-by)

5) Disinfection facility in BPS No.6

a) Specifications of storage container for sodium hypochlorite (produced)

Description	Specification
Type	For solution container
Content	1% sodium hypochlorite
Effective capacity	$1m^3$
Q'ty	4 sets (1set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	1.1 L/min.
Q'ty	2 sets (1set of stand-by)

6) Disinfection facility in BPS No.7

a) Specifications of storage tank for sodium hypochlorite (produced)

Description	Specification
Type	Vertical type polyethylene tank
Content	1% sodium hypochlorite
Effective capacity	$5m^3$
Q'ty	2 sets (1set of stand-by)

b) Specifications of dosing pump (for existing system) for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	1.9 L/min.
Q'ty	2 sets (1set of stand-by)

c) Specifications of dosing pump (for new system) for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	1.9 L/min.
Q'ty	2 sets (1set of stand-by)

d) Specifications of transfer pump for sodium hypochlorite (produced)

Description	Specification
Type	Magnet type dosing pump
Content	1% sodium hypochlorite
Discharge capacity	250 L/min.
Q'ty	2 sets (1set of stand-by)

7) Well No.28

a) Specifications of storage container for sodium hypochlorite (produced)

Description	Specification
Type	For solution container
Content	1% sodium hypochlorite
Effective capacity	$1m^3$
Q'ty	7 sets (1set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	1.6L /min.
Q'ty	2 sets (1set of stand-by)

8) ET No.1

a) Specifications of storage container for sodium hypochlorite (produced)

Description	Specification
Type	For solution container
Content	1% sodium hypochlorite
Effective capacity	$1m^3$
Q'ty	2 sets (1set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	1.4L /min.
Q'ty	2 sets (1set of stand-by)

9) ET No.2

a) Specifications of storage container for sodium hypochlorite (produced)

Description	Specification
Type	For solution container
Content	1% sodium hypochlorite
Effective capacity	$1m^3$
Q'ty	3 sets (1set of stand-by)

b) Specifications of dosing pump for sodium hypochlorite (produced)

Description	Specification
Type	Diaphragm pump
Content	1% sodium hypochlorite
Discharge capacity	1.0L /min.
Q'ty	2 sets (1set of stand-by)

10) Arrangement plan of disinfection facilities

a) BPS No.1

Sodium hypochlorite generation system and dosing system will be installed in the empty space (2 rooms) in the existing distribution pump building and existing facilities will be effectively used. The buildings/structures will be repaired and modified as follows for installing the disinfection facilities in the existing buildings.

- Reinforce the floor in the space to install storage tanks for sodium hypochlorite
- Remove the brick wall between two rooms
- Build RC-sodium hypochlorite dissolving tank outside the building.
- Coating

b) BPS No.7

A new distribution pump building will be constructed in BPS No. 7. Therefore, space must be ensured for installing sodium hypochlorite generation system and dosing system in the distribution pump building to be built, and a combined building for installing distribution pump equipment and disinfection facilities must be constructed.

c) Dosing point at the main water distribution facilities

A building for installing sodium hypochlorite dosing equipment will be constructed at the remaining seven of the main facilities in the water supply system (BPS No. 2, No. 3, No. 5, No. 6, No. 28 well, ET No. 1 and No. 2). The building will be constructed within the premises of the main facilities in the water supply system, and located adjacent to the pumping station, or adjacent to the elevated water tank. Considering workability at the time of sodium hypochlorite containers coming into the building, the container should be directly received from pallets of the delivery vehicles in the plan.

2－2－2－2. Equipment Plan

The number of house connections required during the detailed design of 2015 was estimated in "2-2-2-1 (4) a)." However the population from 2015 up to the target year 2020 is expected to increase and new houses will be constructed; thus, households desiring new connections are anticipated to increase.

The number of water service equipment for the households desiring new house connection will be procured as a part of Equipment Plan, to carry out adequate non-revenue water reduction measures by maintaining accuracy and quality of water service equipment required up to the target year 2020.

(1) Scope for water service equipment (service pipes and water meters) in the Project

Out of the two scopes for procurement and construction (pipe laying work) of water service

equipment such as service pipes and water meters defined in "2-2-2-1 (4) a)", No. 2: Procurement of water service equipment as part of the Equipment Plan, is described here. As shown in the definitions of Table 2-13, the procurement of materials and equipment of house connections will be implemented in the grant aid cooperation and pipe laying work will be done by the Myanmar side.

The number of water service equipment to be procured as a part of Equipment Plan is estimated below.

1) Planned served population in the target year (2020) of the Project: 51,919
2) No. of persons per household: 5.8
3) No. of households estimated from planned served population (1)/2)): 8,952 households
4) The number of house connections to be procured and laid as a part of Construction Plan: 8,309 connections

Source: 1) JICA Study Team calculated value 2) Survey results of social conditions

The number of house connections required in the target year (2020) can be estimated as 8,952 connections from the number of households corresponding to the planned served population by defining the provision of one connection per household. The number of house connections to be procured and laid as a part of Construction Plan is estimated as 8,309, which is 643 connections less than the number of house connections required in 2020. These 643 connections will be the number of water service equipment as a part of Equipment Plan.

Later on, the number of house connections to be procured and laid as a part of Construction Plan will be finally decided by using and reviewing the result of field survey during the detail design stage (assuming in 2015), information on registration record of residence stored in the MCDC Township office of the Pyi Gyi Tagon TS that administer the target service area, the confirmed number of requirement of house connection, and willingness to connect.

On the other hand, the number of house connections required in the target year (8,952) is set as the maximum number; therefore, the number of connections (643) for procuring water service equipment as a part of Equipment Plan will also be reviewed simultaneously.

The contents of 643 sets of water service equipment are as shown below.

Table 2-20 Contents of water service equipment

Equipment	Specifications	Quantity
Saddle	DN 150, 100, 50 mm ×13 mm, made of cast iron	643
Service pipe	DN 13 mm、PE pipe, L=5.5m /set, metal joint (2 elbows/set, 1 socket/set and 1 union/set)	643 sets
Stop valve	13 mm stop valve with non-return valve	643
Water meter	13 mm direct reading type with strainer	643
Water meter box	For 13 mm	643

The procured water service equipment will be installed by the Myanmar side. To secure construction quality, the Contractor shall conduct OJT (On-the-Job Training) to the Department of Water and Sanitation, MCDC and local construction companies providing installation of house connection.

1) Delivery destination and user of procured equipment

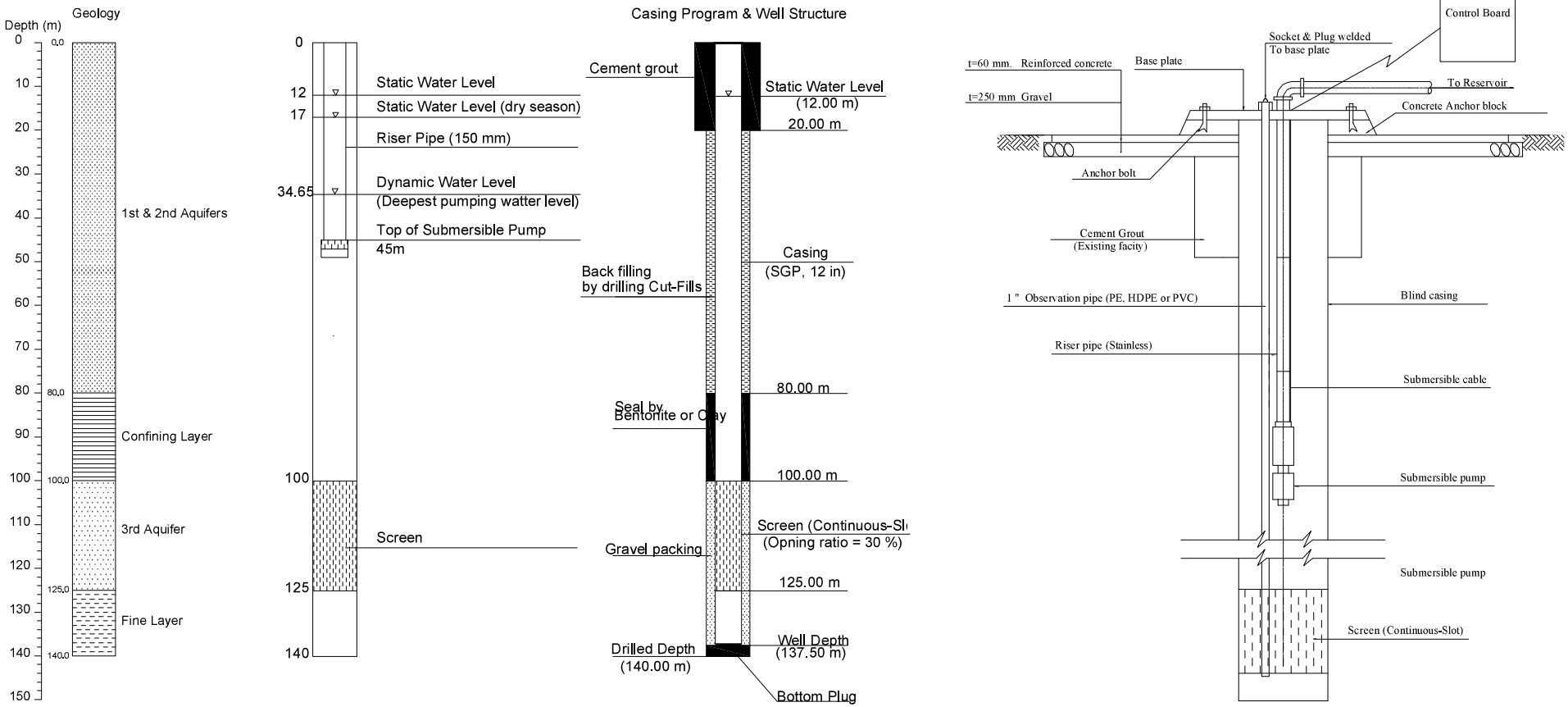
Water Distribution Section, Department of Water and Sanitation, MCDC

2) Storage location

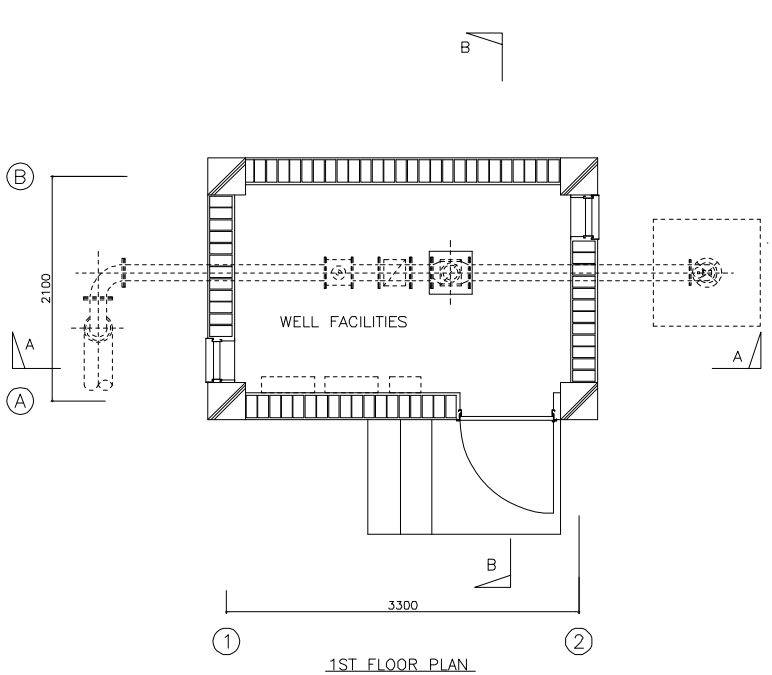
Warehouse managed by Department of Water and Sanitation in MCDC

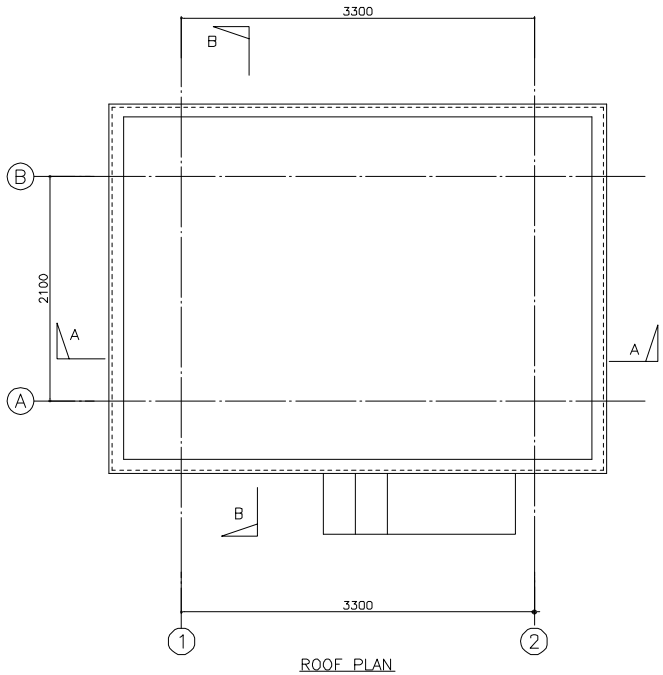
2－2－3. Outline Design Drawing

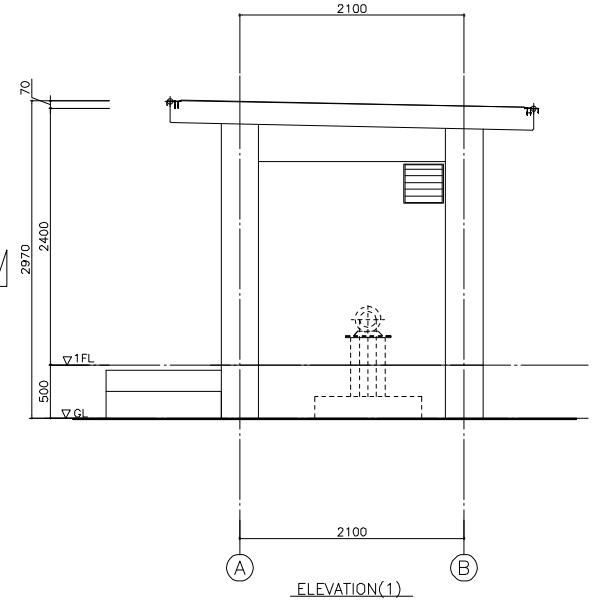
DWG No.	Tittle	Scale
DWG-1	Well structure	-
DWG-2	Intake well facility	1:50
DWG-3	General layout of No. 7 pump station	1:300
DWG-4	Plan of distribution reservoir in No. 7 pump station	1:100
DWG-5	Section of distribution reservoir in No. 7 pump station	1:100
DWG-6	First floor plan of distribution pump station in No. 7 pump station	1:100
DWG-7	Section of distribution pump station in No. 7 pump station	1:100
DWG-8	Plan of transmission pipeline	1:5000
DWG-9	Plan of distribution main pipeline (1)	1:5000
DWG-10	Plan of distribution main pipeline (2)	1:5000
DWG-11	Plan of distribution main pipeline (3)	1:5000
DWG-12	Plan of distribution main pipeline (4)	1:5000
DWG-13	Route of distribution branch and small pipeline	-
DWG-14	General plan of chlorination facility in No.1 pump station	1:300
DWG-15	Plan of chlorination facility in No.1 pump station	1:100
DWG-16	General plan and structure of disinfection facility in No.2 pump station	1:100, 1:600
DWG-17	General plan and structure of disinfection facility in No.3 pump station	1:100, 1:600
DWG-18	General plan and structure of disinfection facility in No.5 pump station	1:100, 1:600
DWG-19	General plan and structure of disinfection facility in No.6 pump station	1:100, 1:600
DWG-20	General plan and structure of disinfection facility in well No.28	1:100, 1:600
DWG-21	General plan and structure of disinfection facility in No.1 elevated tank	1:100, 1:600
DWG-22	General plan and structure of disinfection facility in No.2 elevated tank	1:100, 1:600

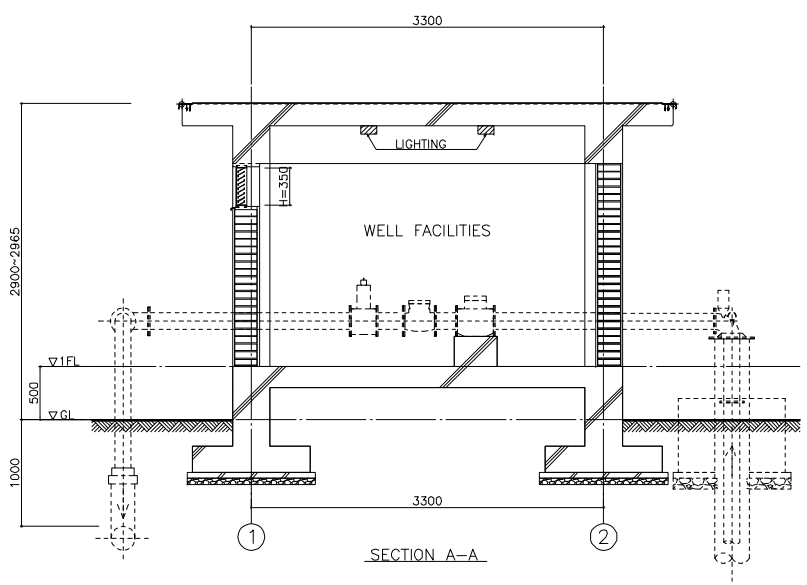


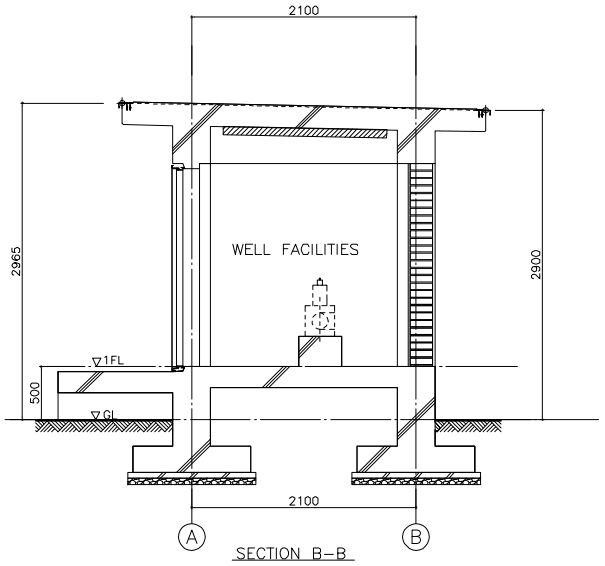
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Well Structure	SCALE : NONE DRAWING NO. : 1	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

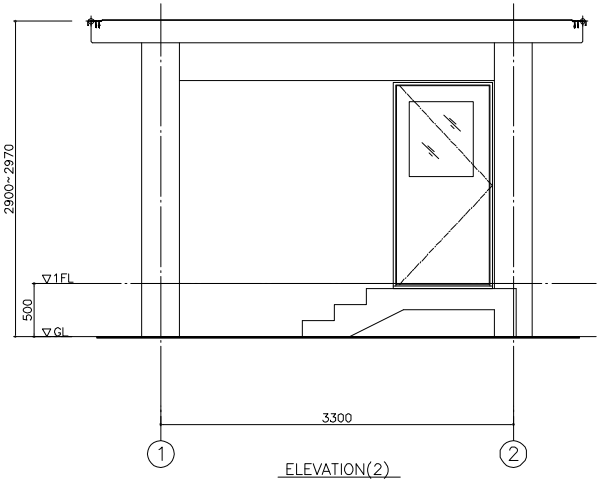




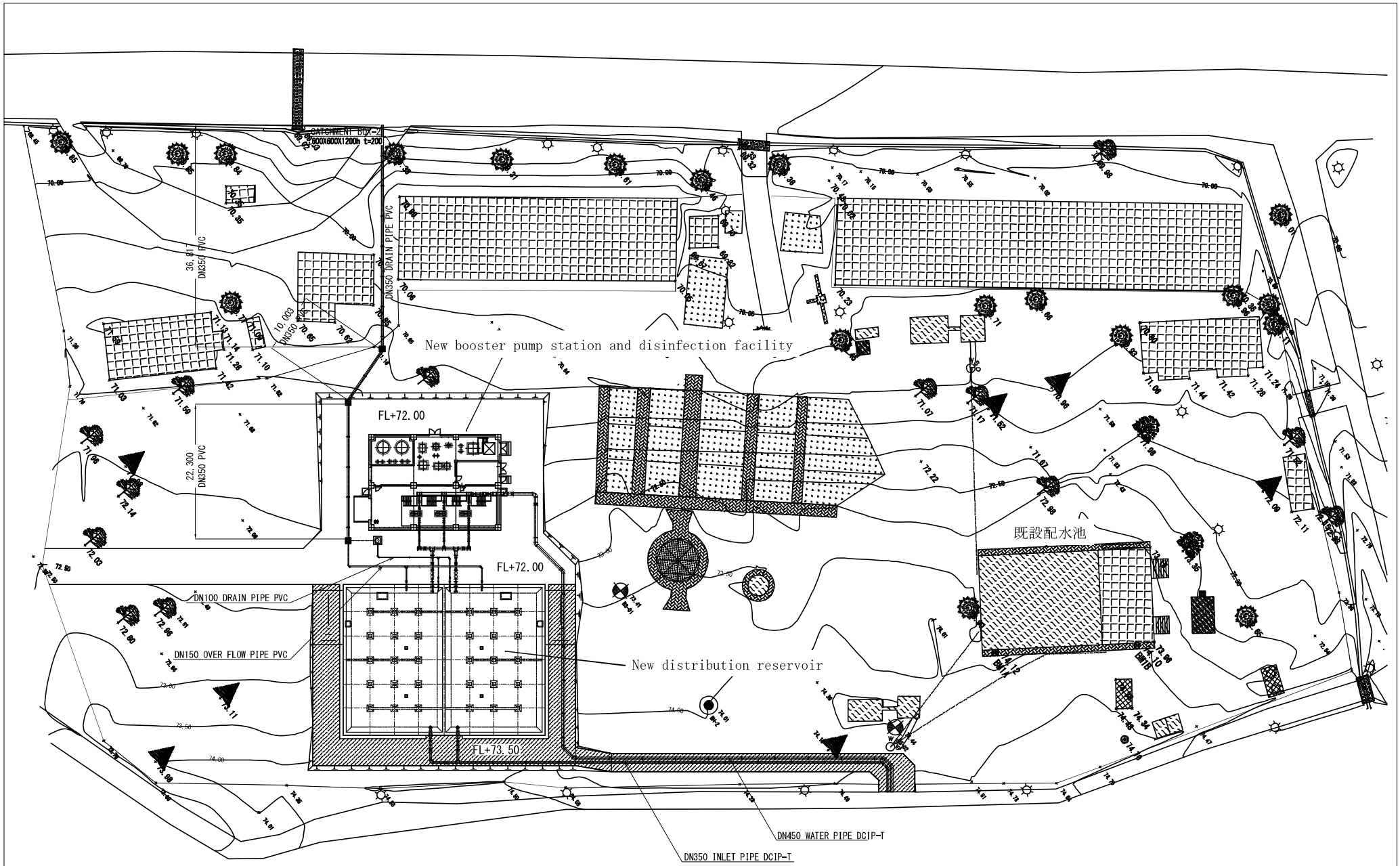




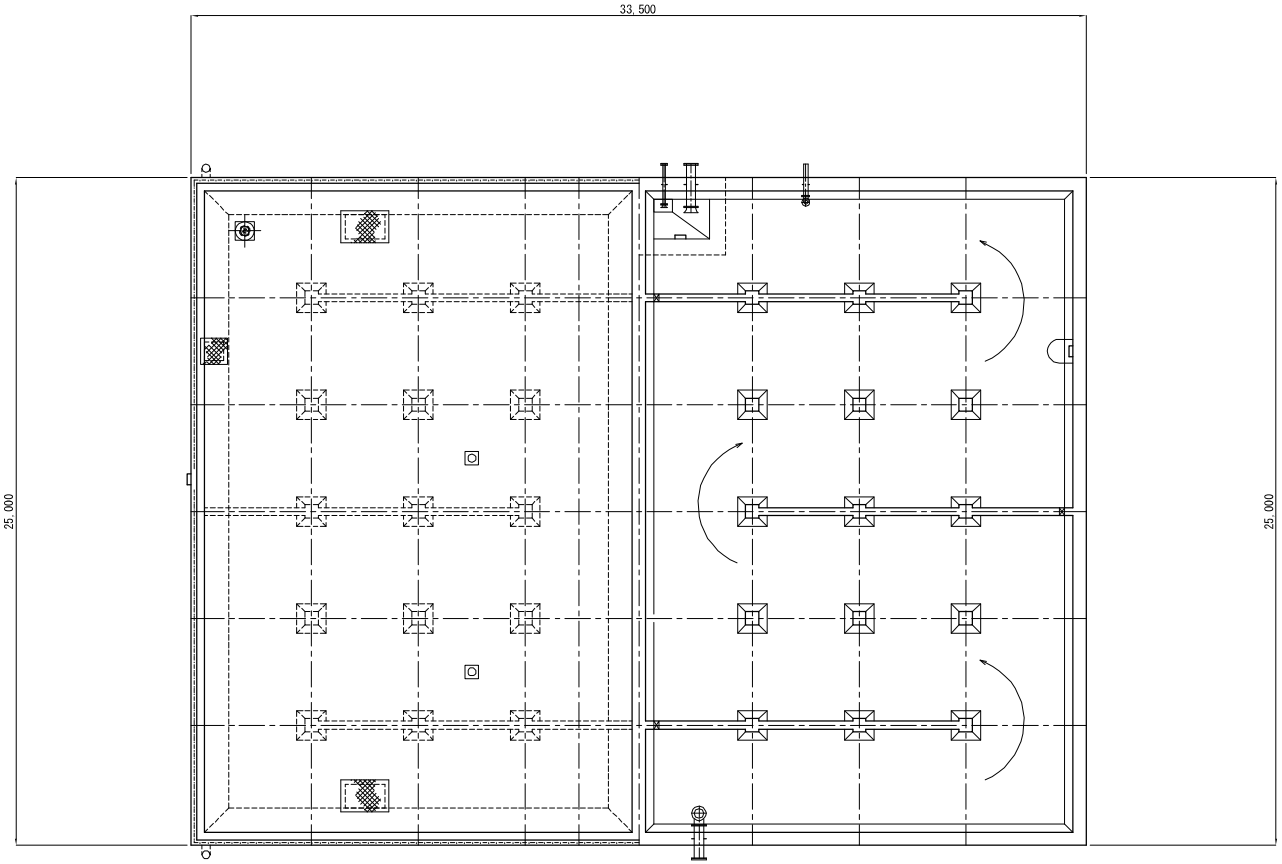




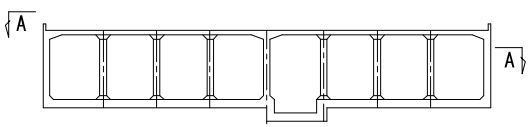
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Intake well facility	SCALE : S=1:50 DRAWING NO. : 2	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014



REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General layout of No. 7 pump station	SCALE : 1:300 DRAWING NO. : 3	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

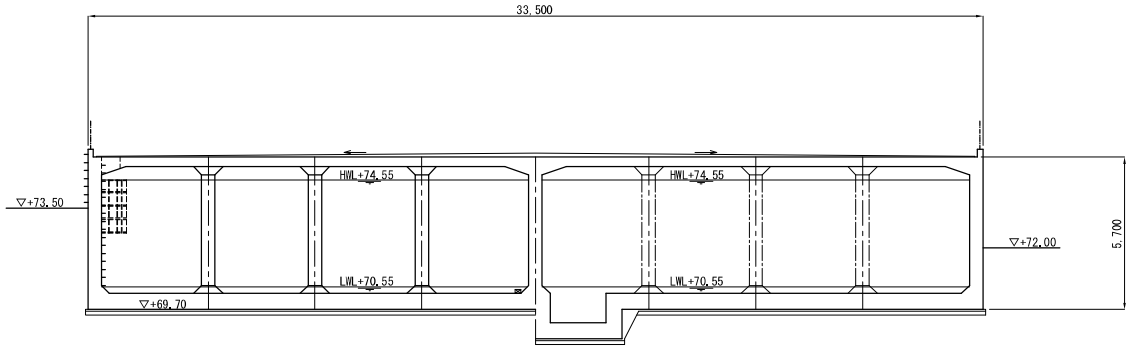


KEY PLAN

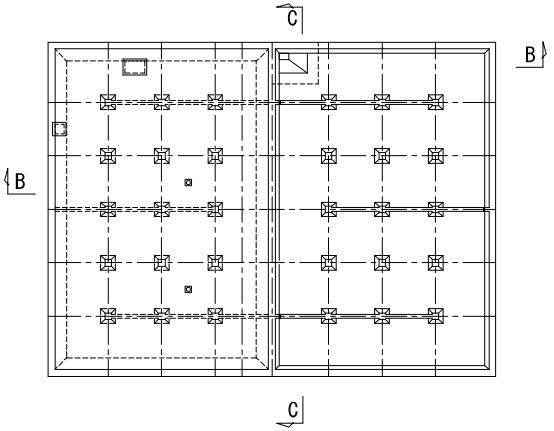


REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Plan of distribution reservoir in No. 7 pump station	SCALE : 1:100 DRAWING NO. : 4	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

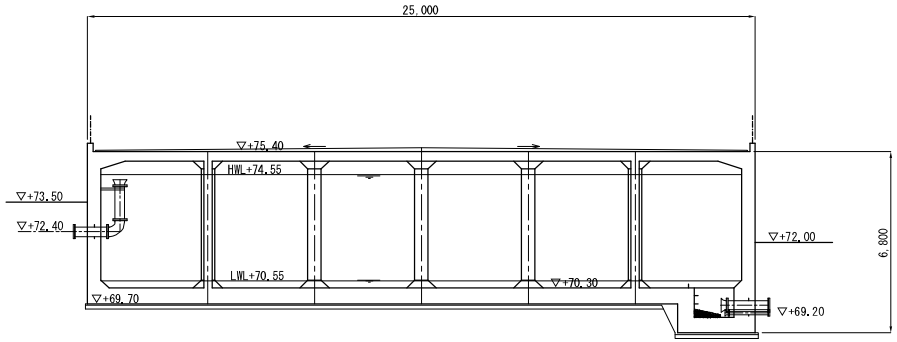
SECTION B-B



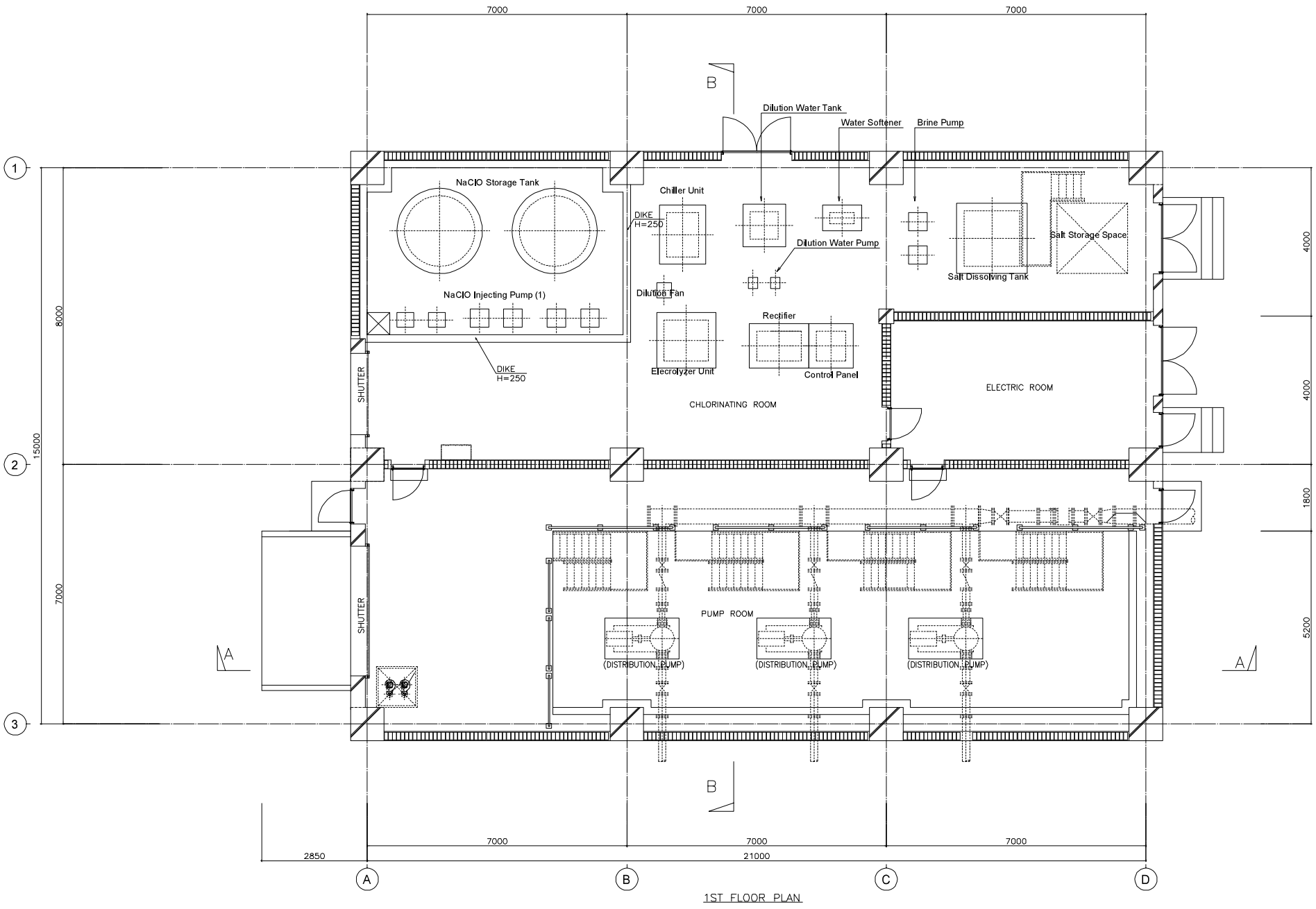
KEY PLAN



SECTION C-C

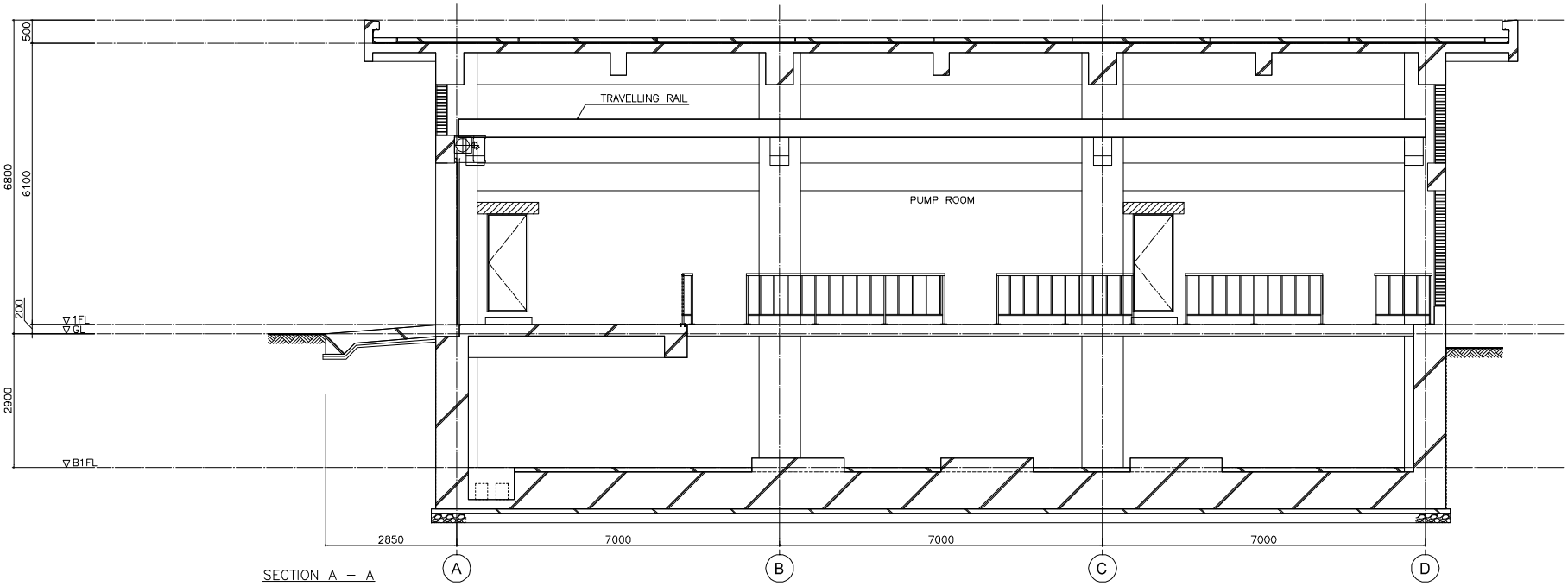


REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Section of distribution reservoir in No.7 pump station	SCALE : 1:100 DRAWING NO. : 5	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

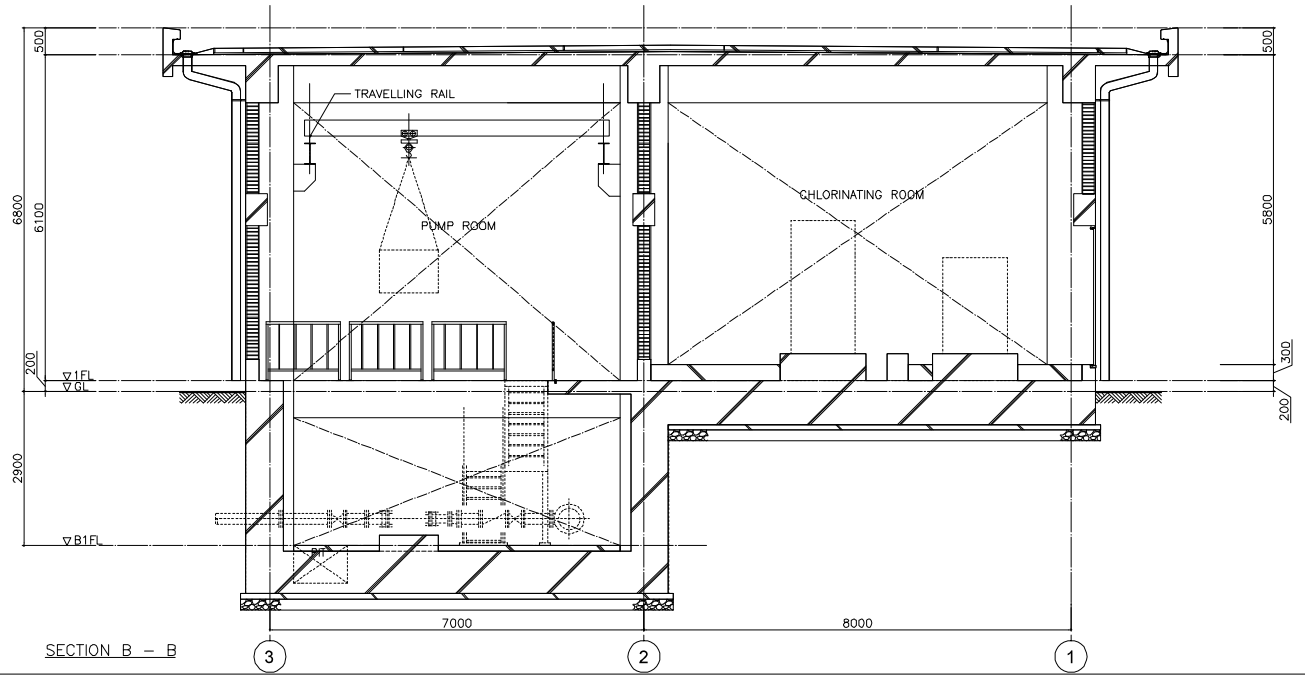


1ST FLOOR PLAN

REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : First floor plan of distribution pump station in No. 7 pump station	SCALE : S=1:100 DRAWING NO. : 6	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

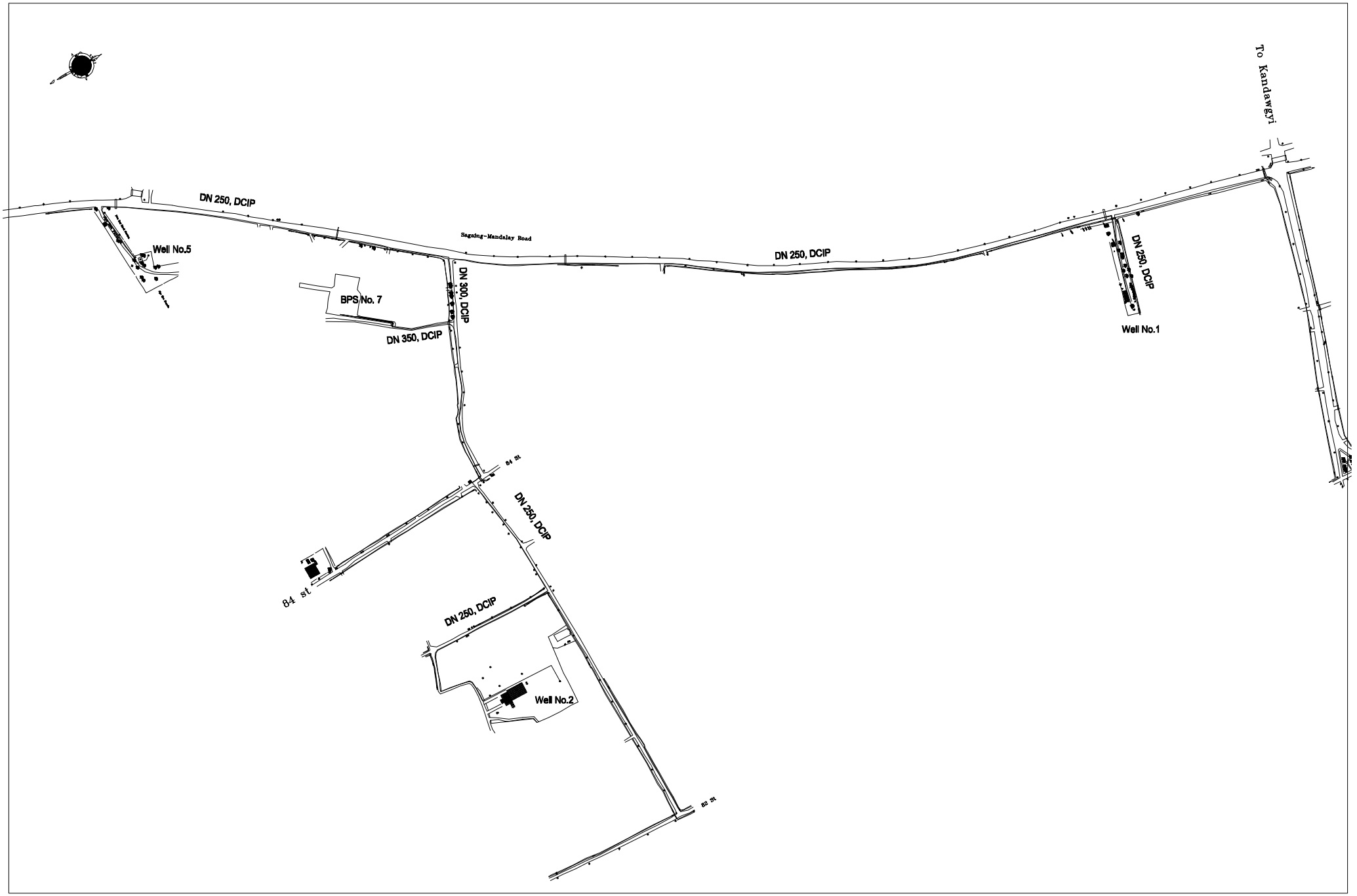


SECTION A – A

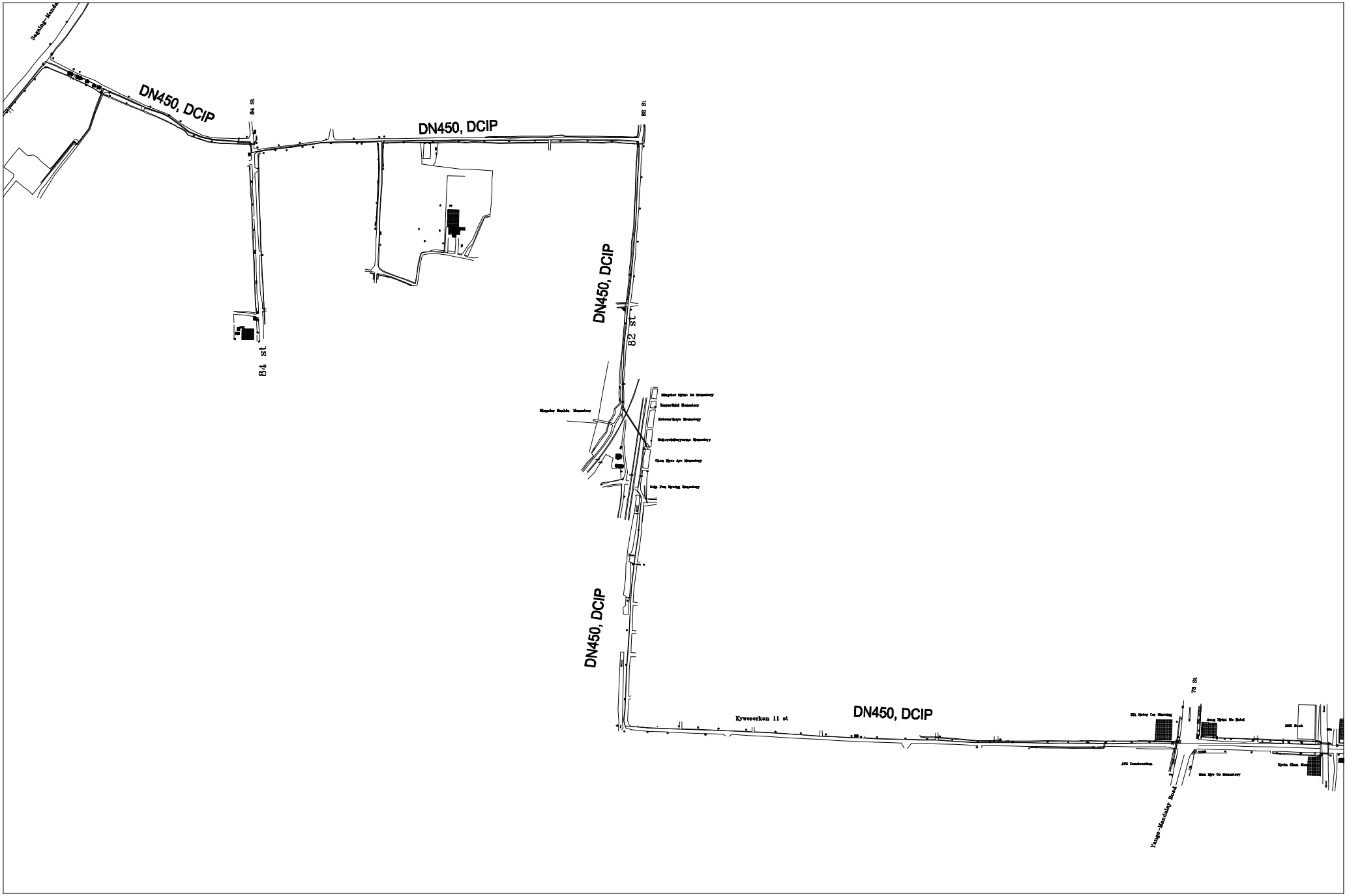


SECTION B – B

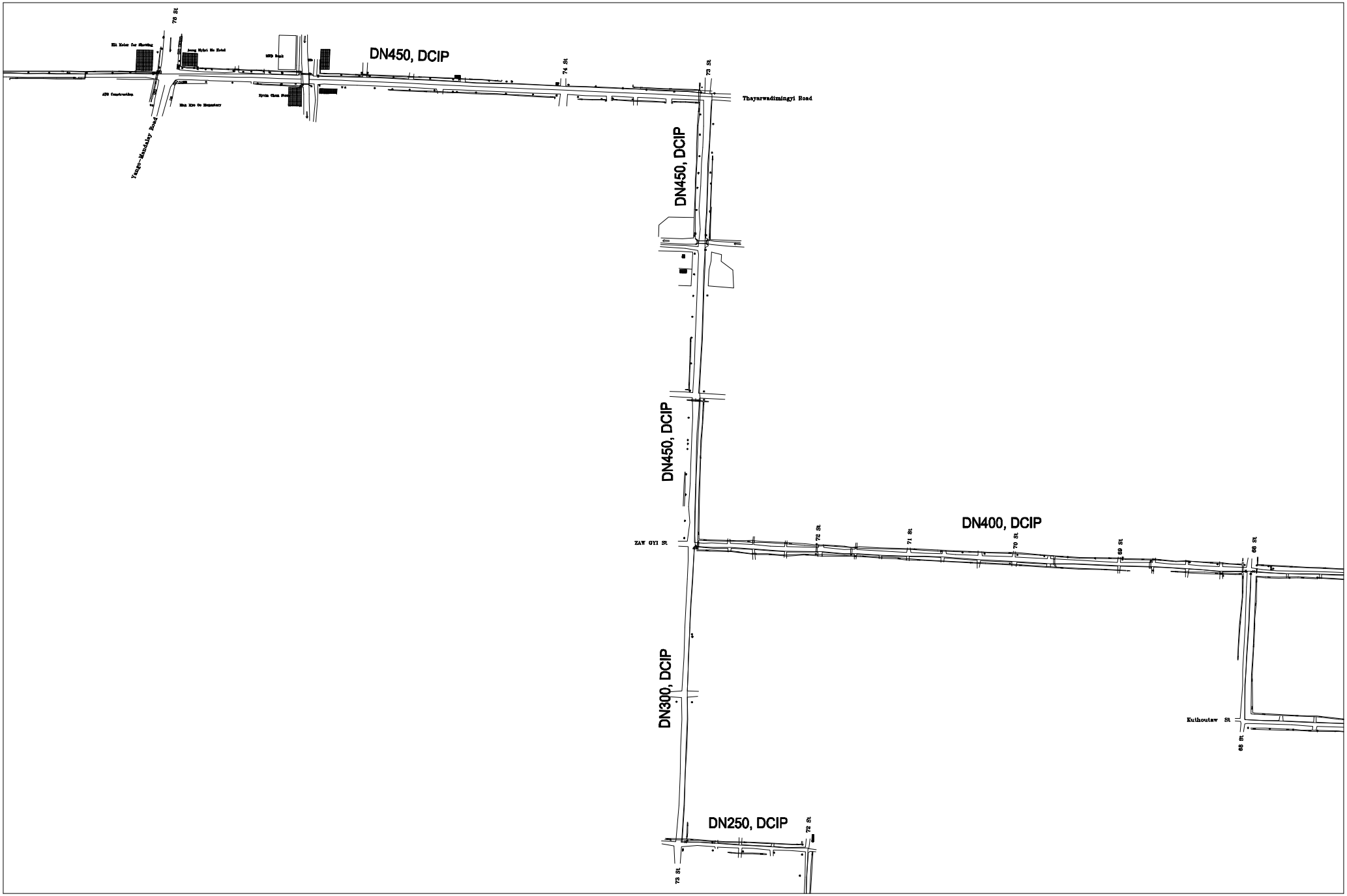
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Section of distribution pump station in No. 7 pump station	SCALE : S=1:100 DRAWING NO. : 7	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014



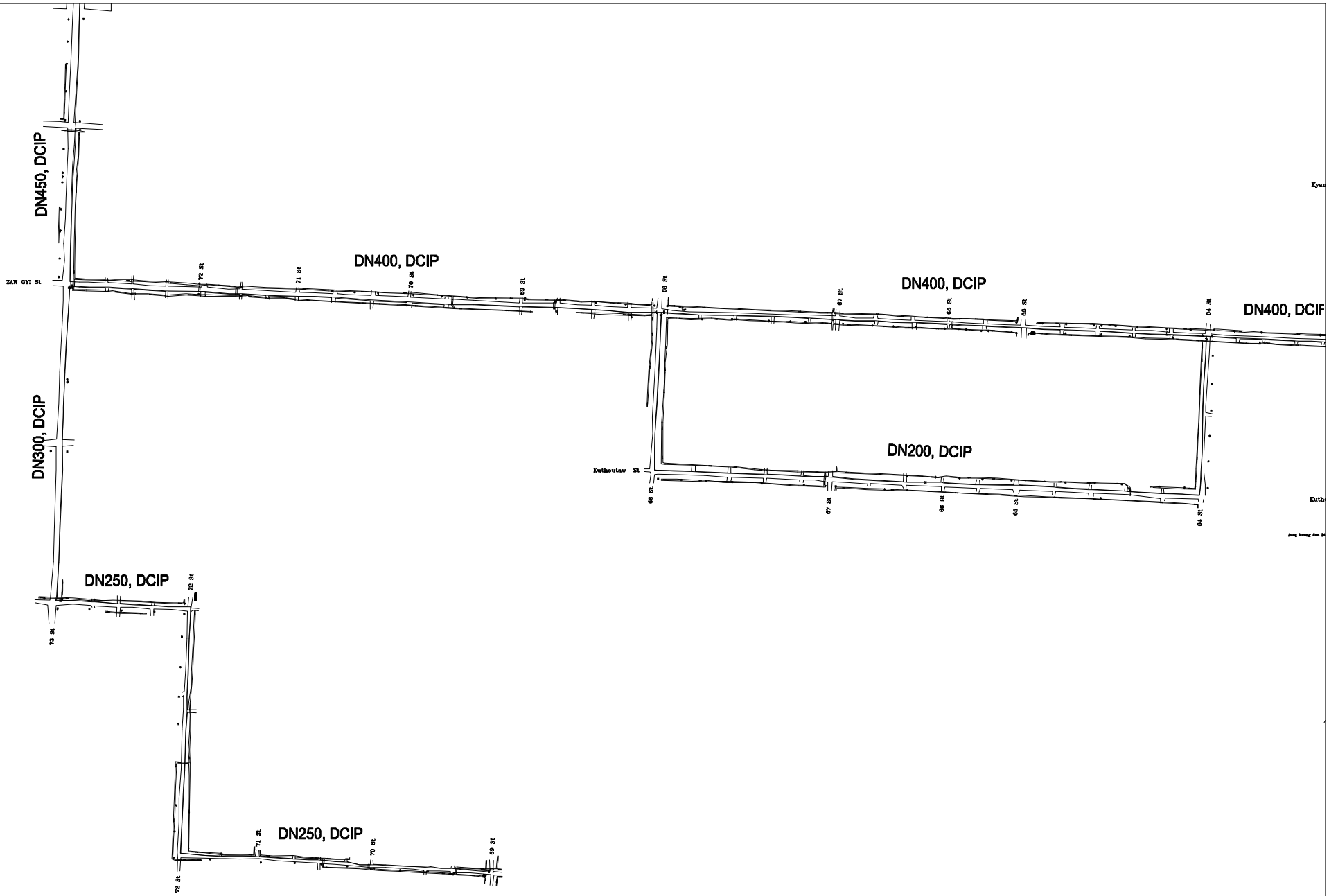
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Plan of transmission pipeline	SCALE : 1:5000 DRAWING NO. : 8	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014



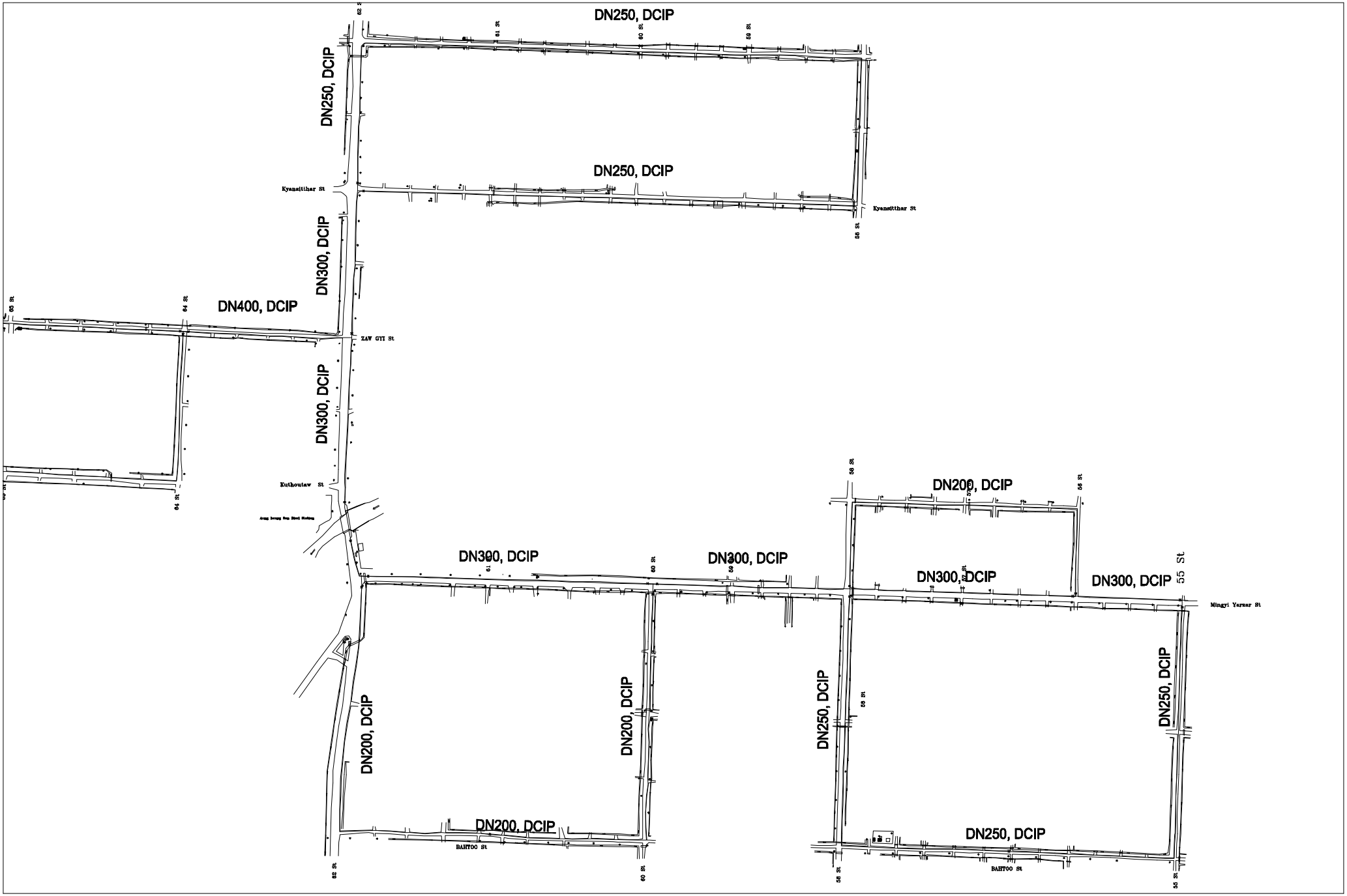
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Plan of distribution main pipeline (1)	SCALE : 1:5000 DRAWING NO. : 9	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014



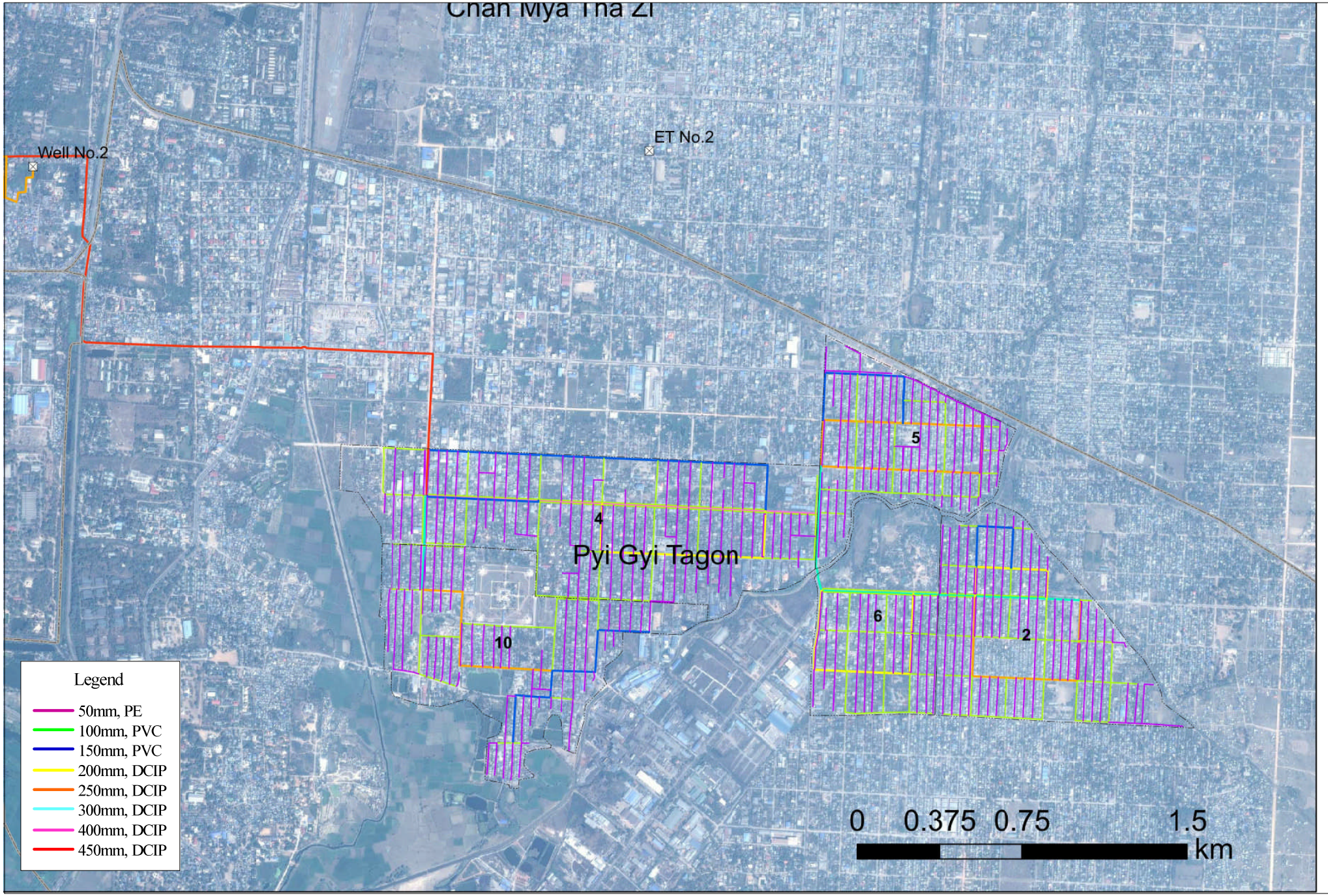
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Plan of distribution main pipeline (2)	SCALE : 1:5000 DRAWING NO. : 10	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014



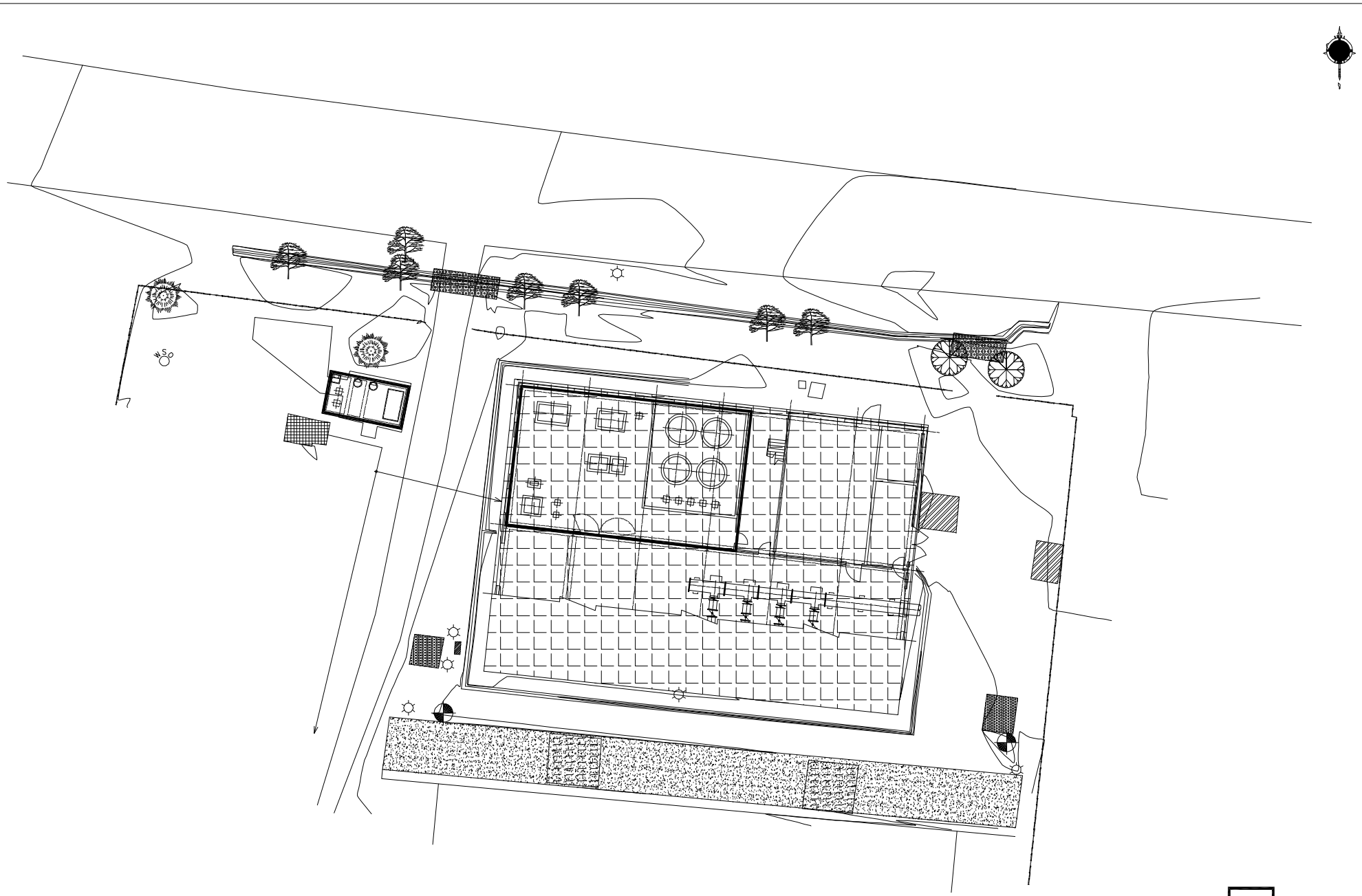
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Plan of distribution main pipeline (3)	SCALE : 1:5000 DRAWING NO. : 11	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014



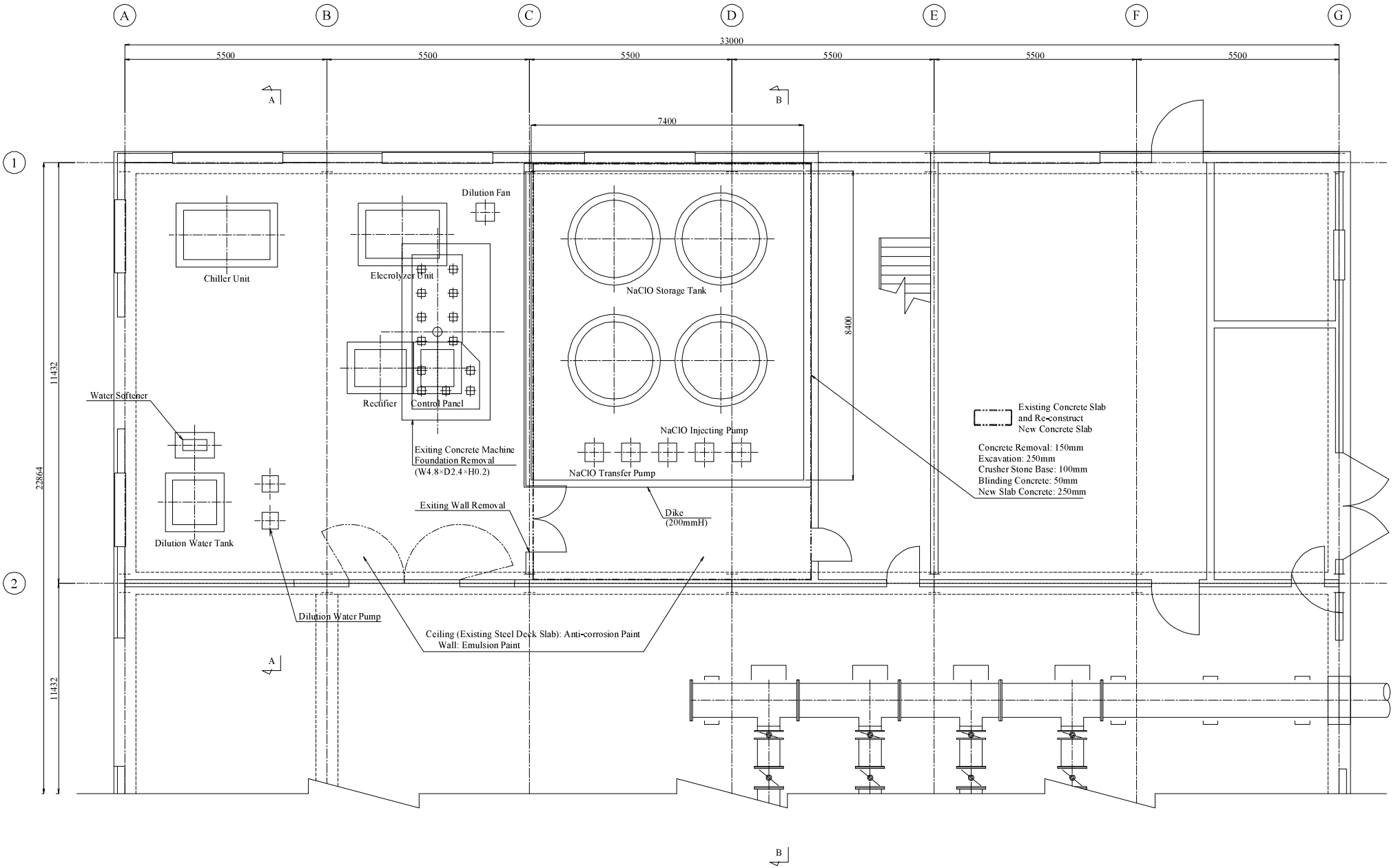
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Plan of distribution main pipeline (4)	SCALE : 1:5000 DRAWING NO. : 12	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014



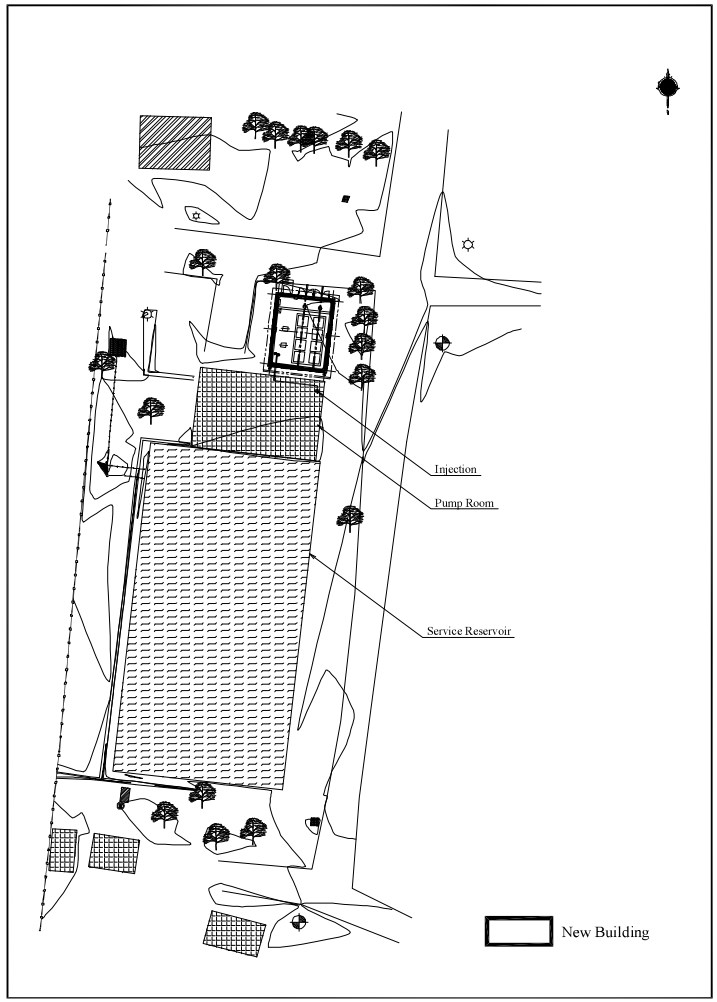
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Route of distribution branch and small pipeline	SCALE : – DRAWING NO. : 13	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

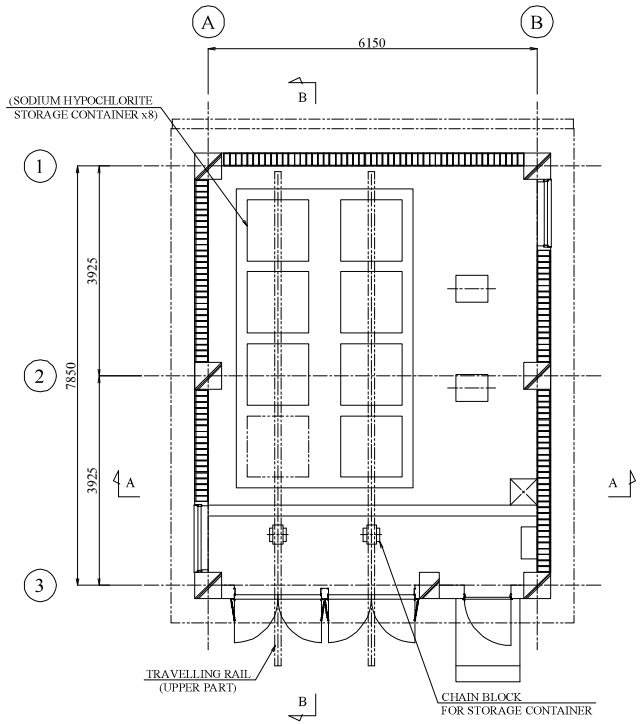


REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan of chlorination facility in No.1 pump station e	SCALE : 1:300 DRAWING NO. : 14	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

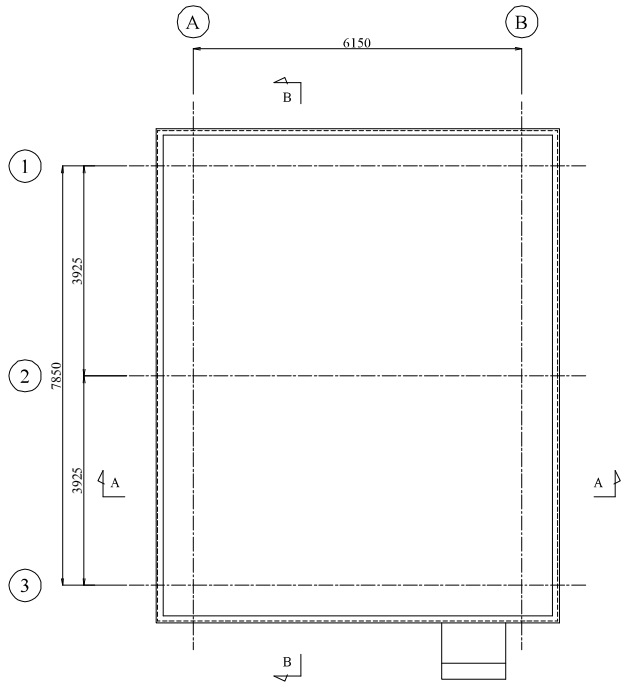


REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : Plan of chlorination facility in No.1 pump station	SCALE : 1:100 DRAWING NO. : 15	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014





1ST FLOOR PLAN



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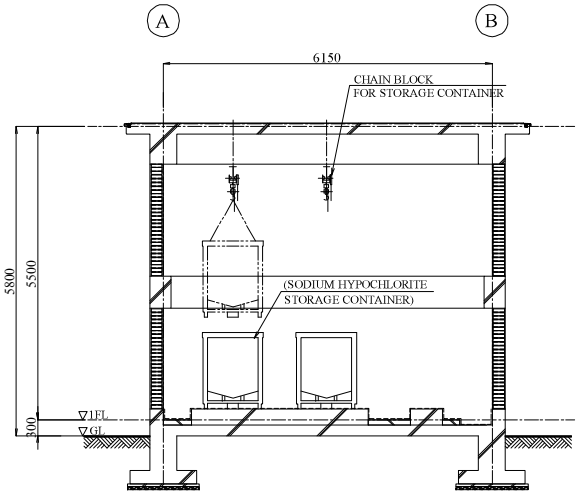

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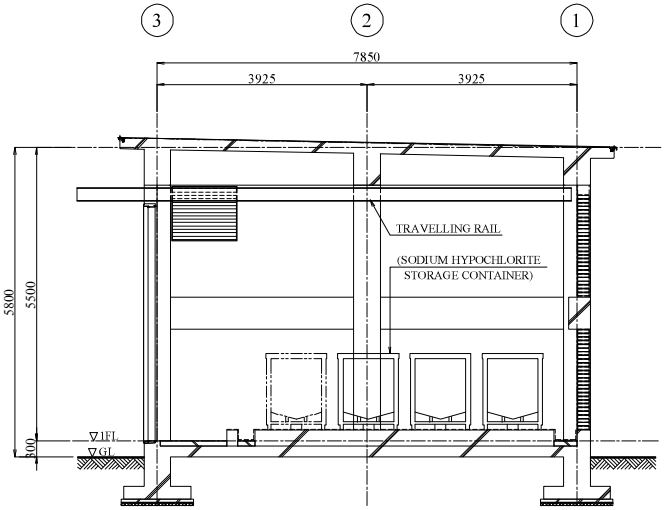

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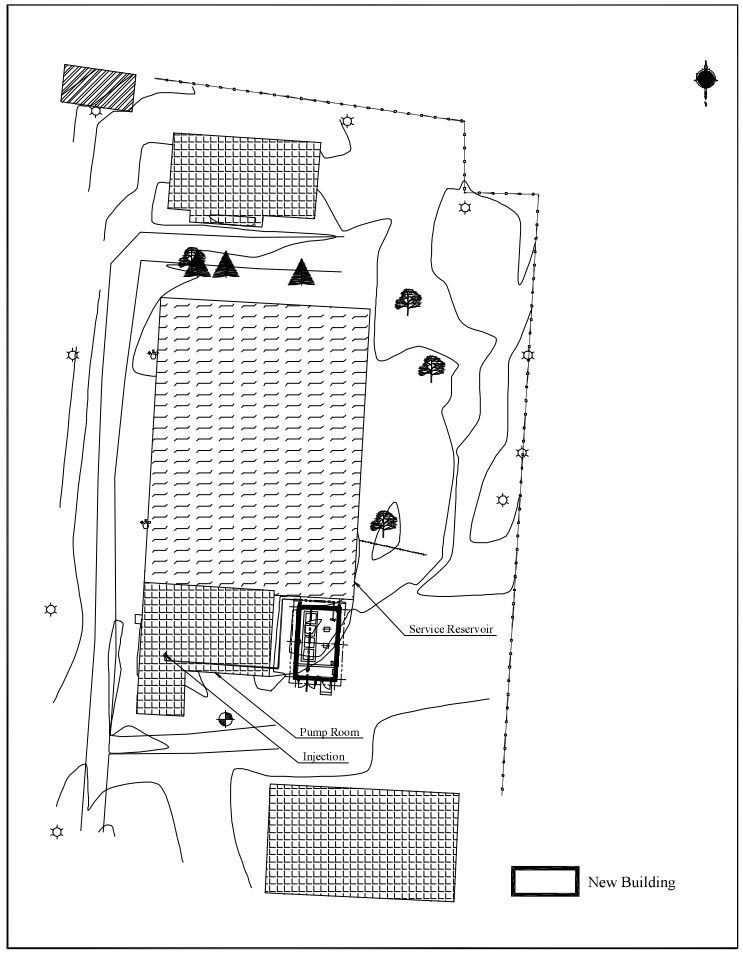
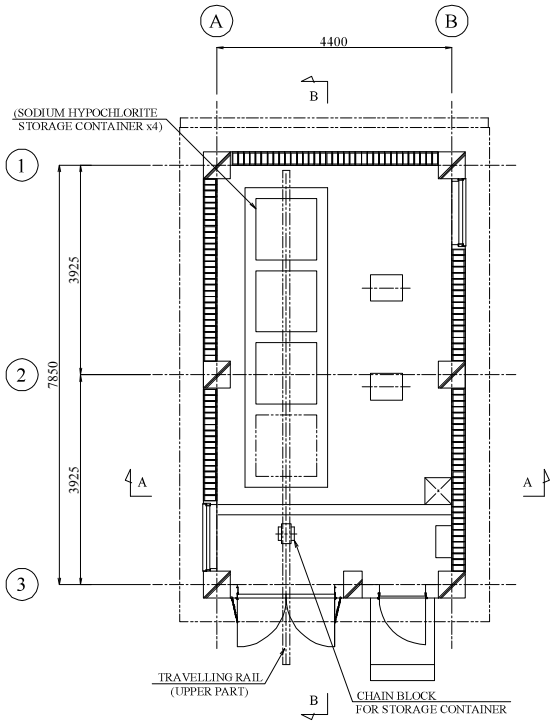
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan and structure of disinfection facility in No.2 pump station	SCALE : 1:600, 1:100 DRAWING NO. : 16	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014





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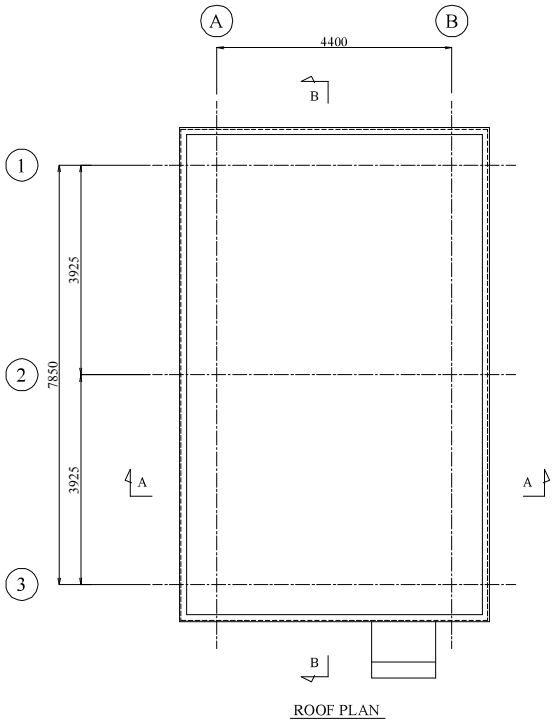

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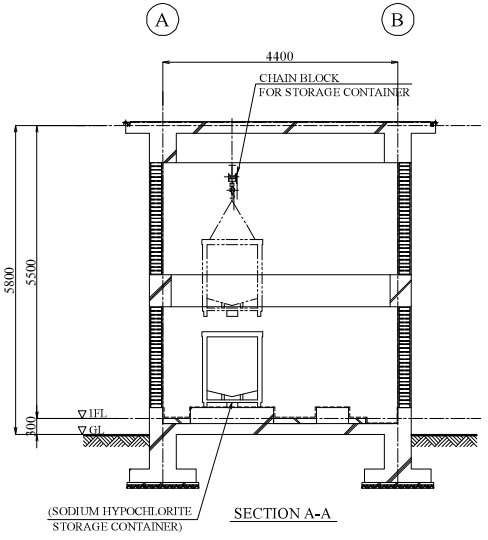
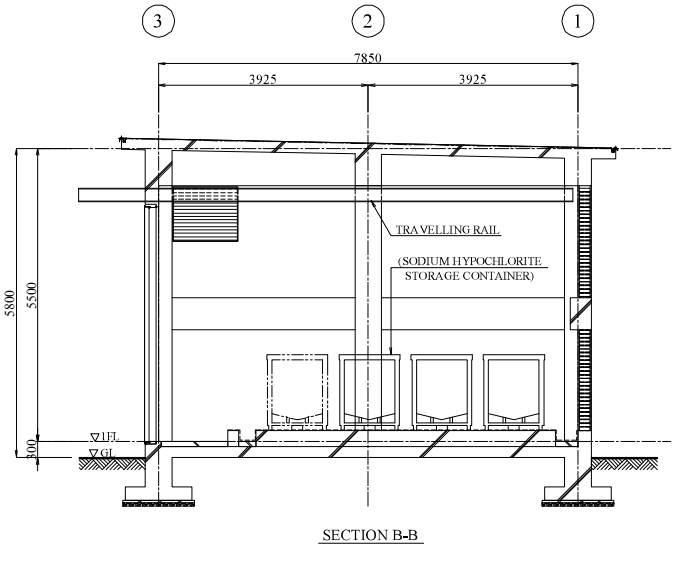


SECTION A-A



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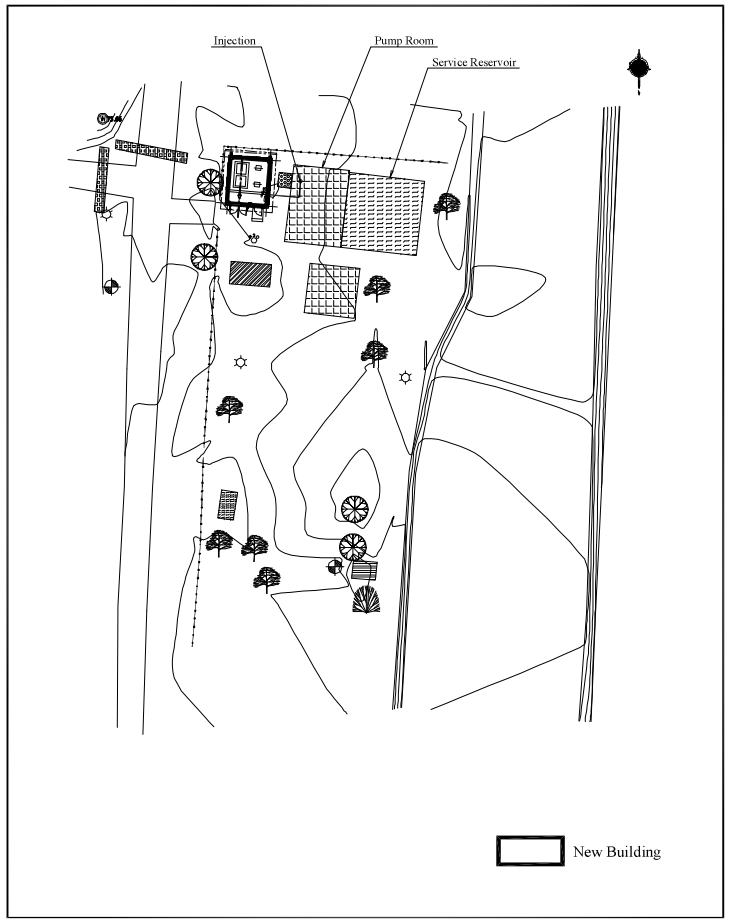
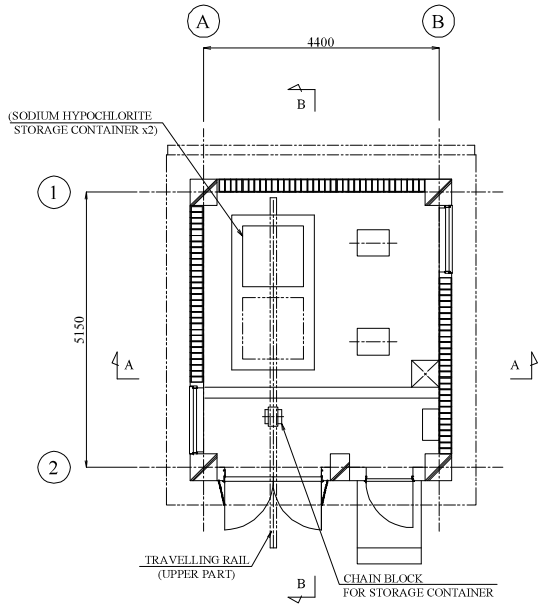
REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan and structure of disinfection facility in No.3 pump station	SCALE : 1:600, 1:100 DRAWING NO. : 17	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014





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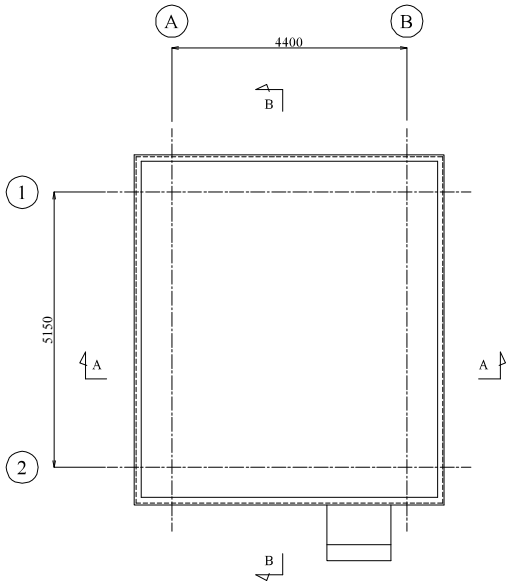

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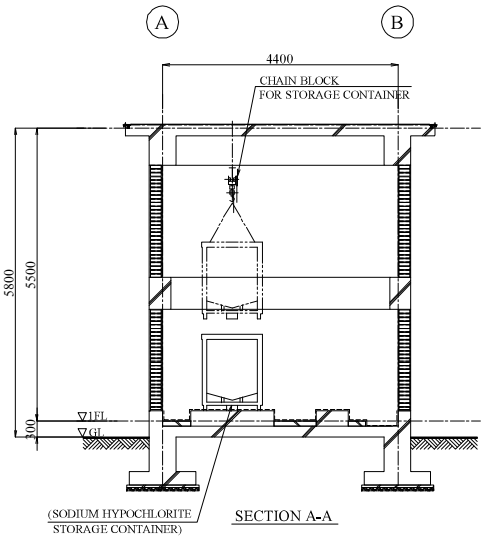
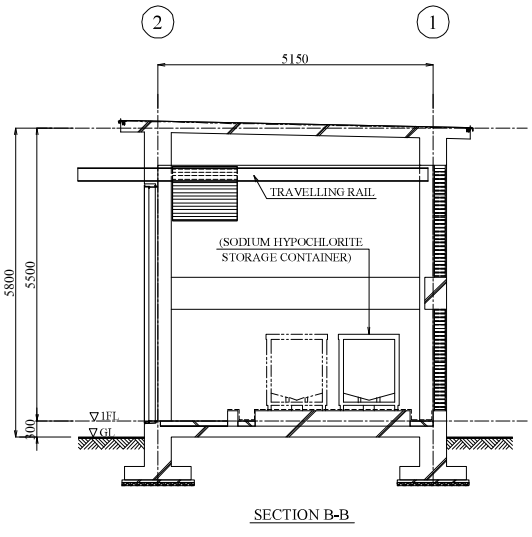
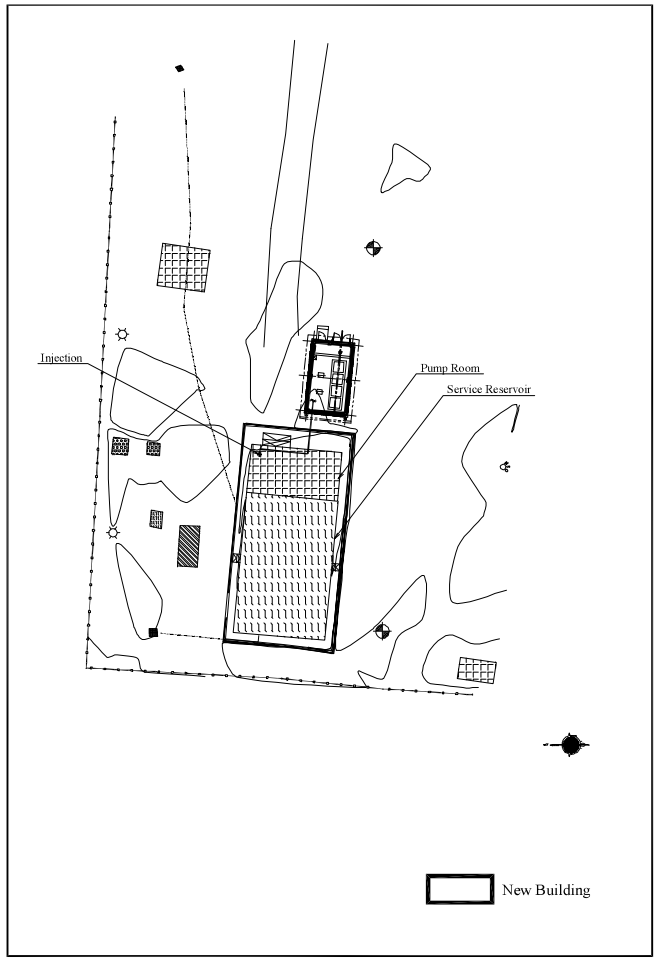


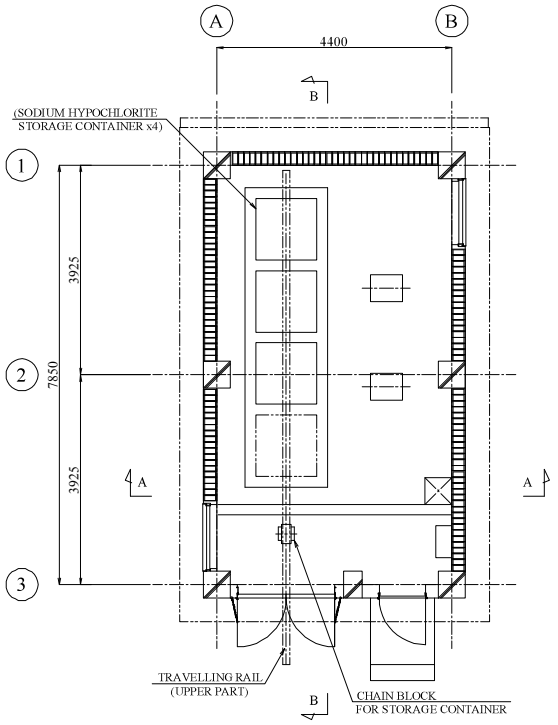
SECTION A-A



SECTION B-B

REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan and structure of disinfection facility in No.5 pump station	SCALE : 1:600, 1:100 DRAWING NO. : 18	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014





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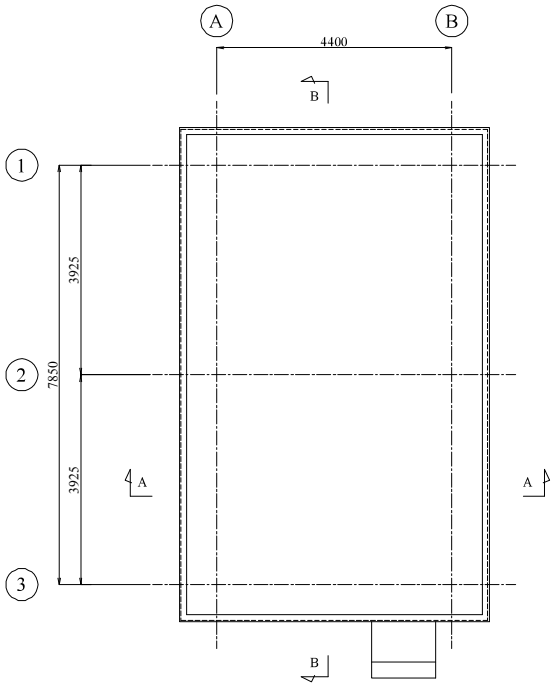

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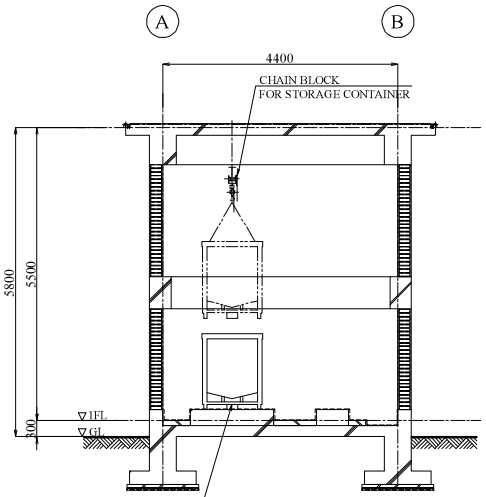
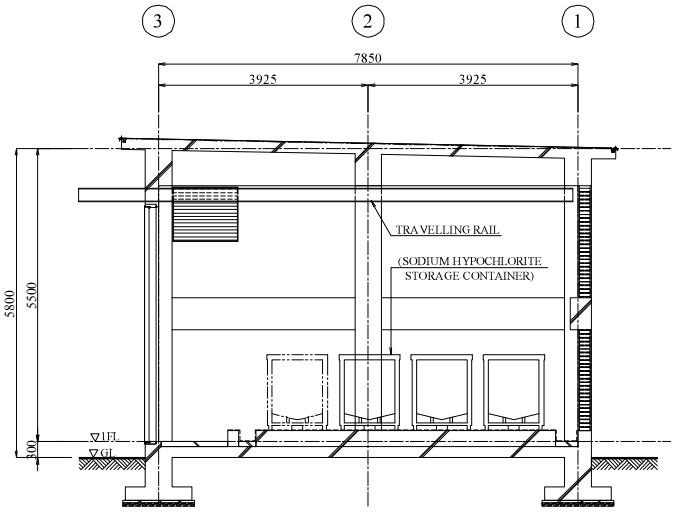
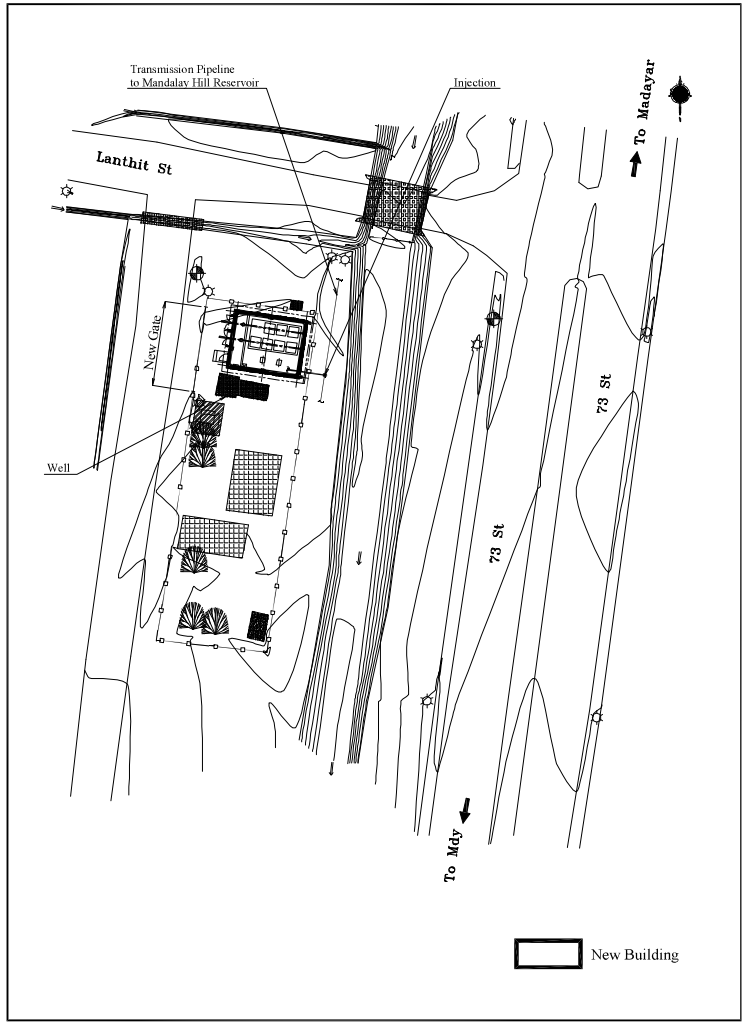


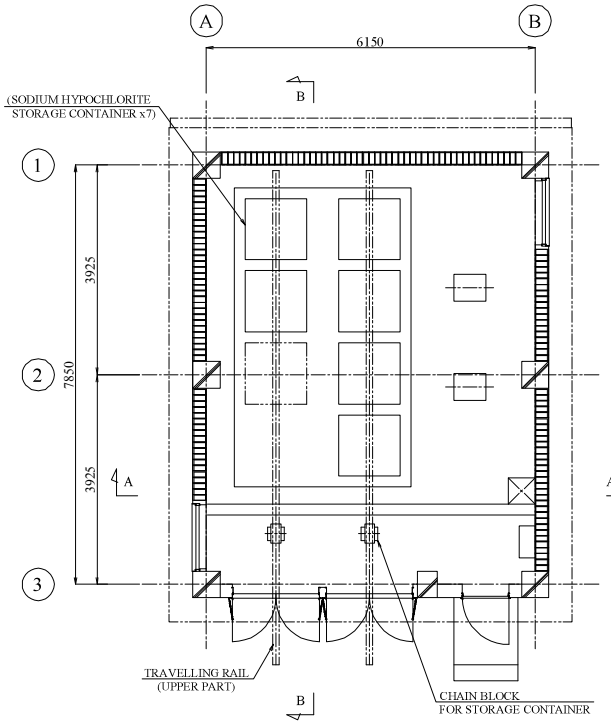
SECTION A-A



SECTION B-B

REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan and structure of disinfection facility in No.6 pump station	SCALE : 1:600, 1:100 DRAWING NO. : 19	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014





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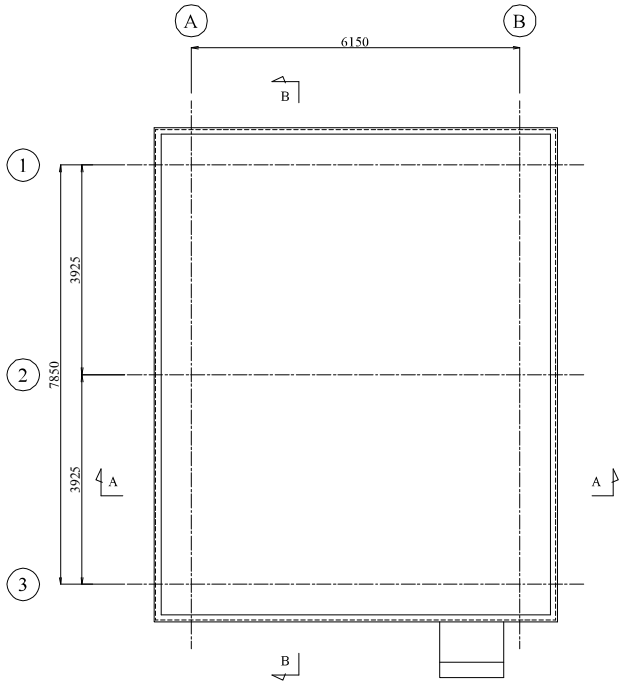

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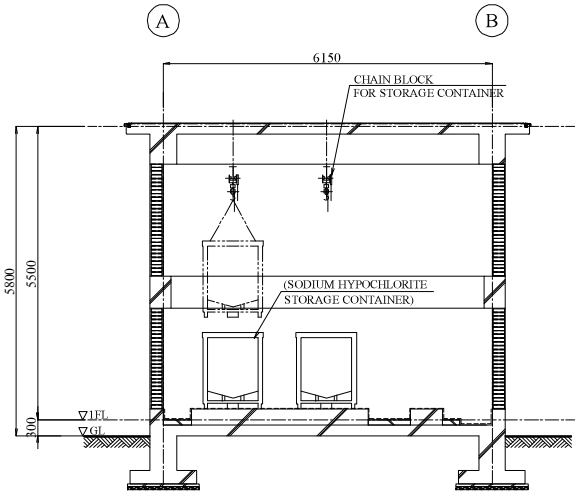

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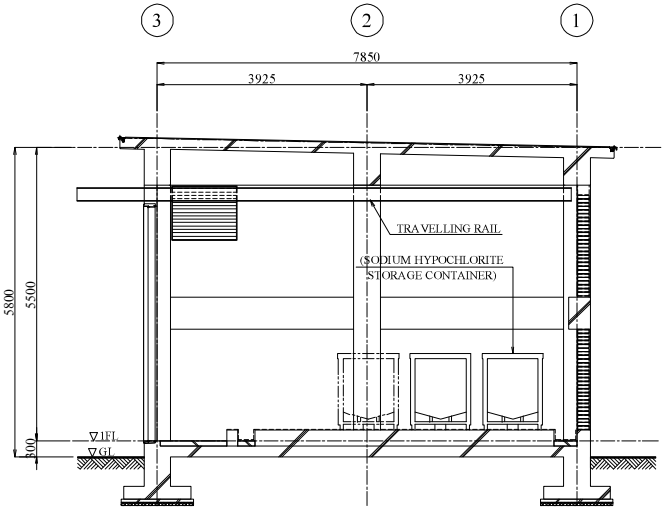
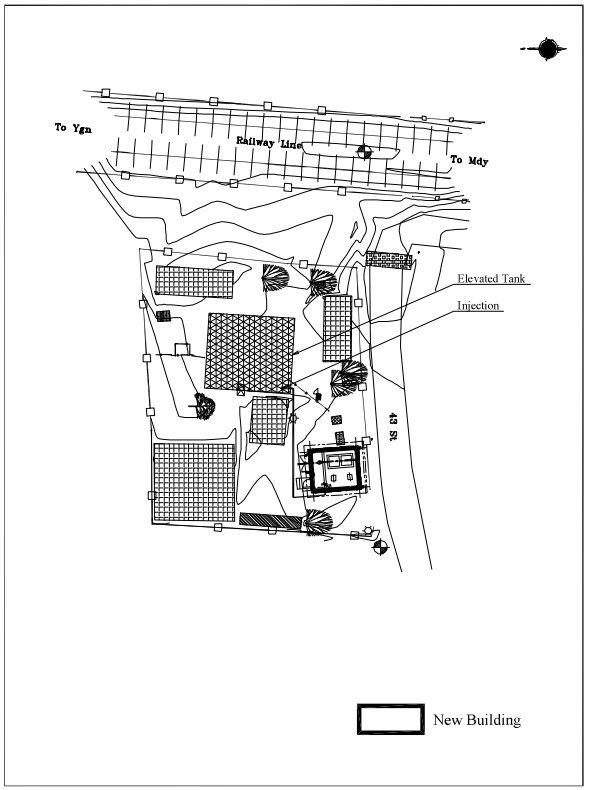
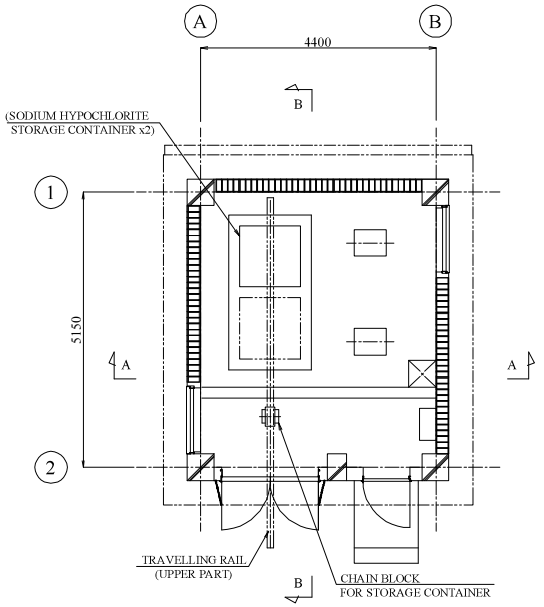


SECTION B-B

REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan and structure of disinfection facility in well No.28	SCALE : 1:600, 1:100 DRAWING NO. : 20	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014





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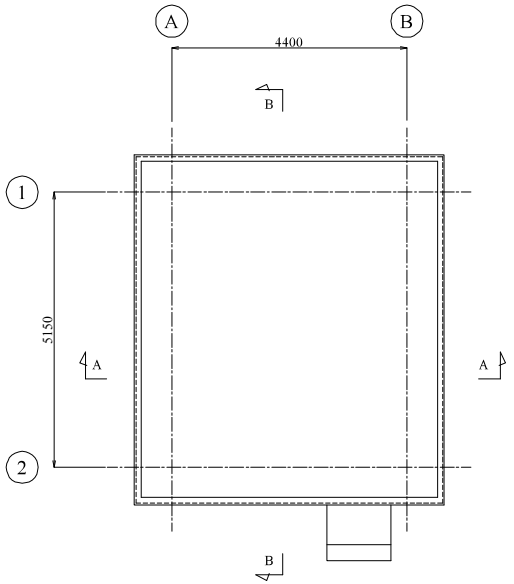

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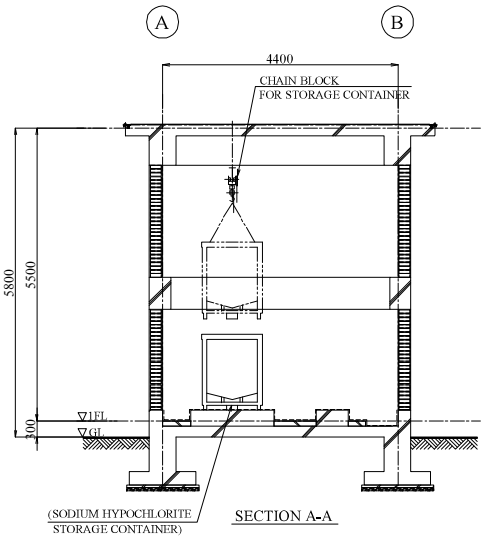
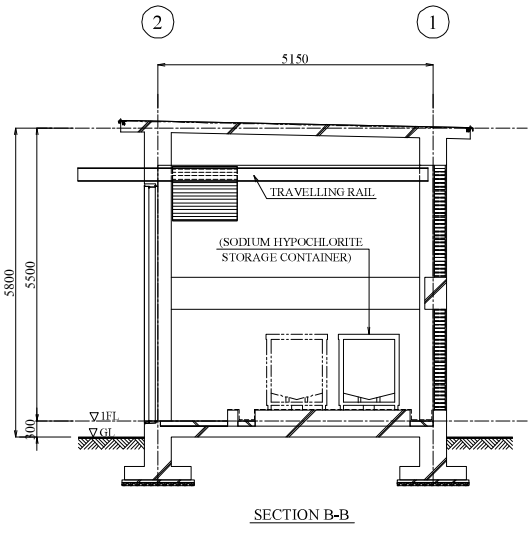
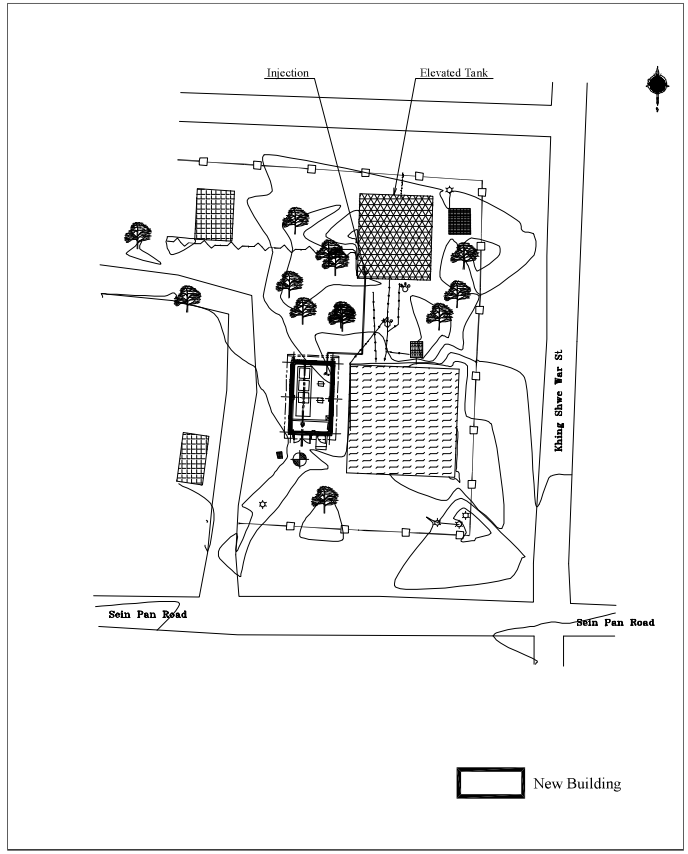


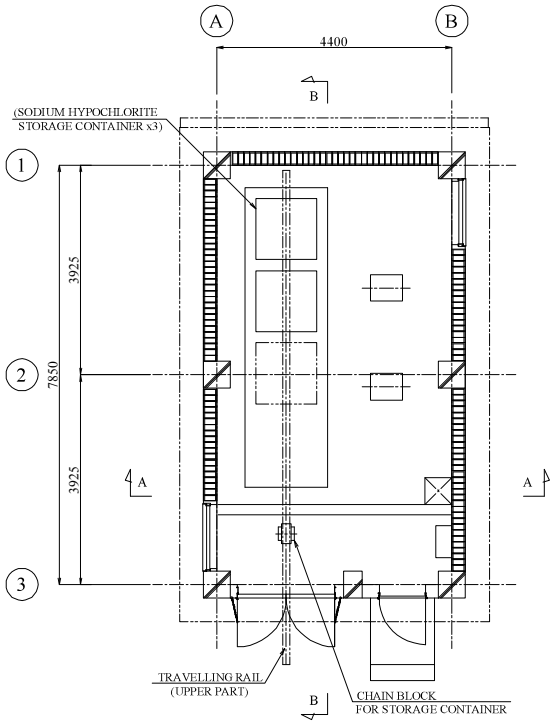
SECTION A-A



SECTION B-B

REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan and structure of disinfection facility in No.1 elevated tank	SCALE : 1:600, 1:100 DRAWING NO. : 21	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014





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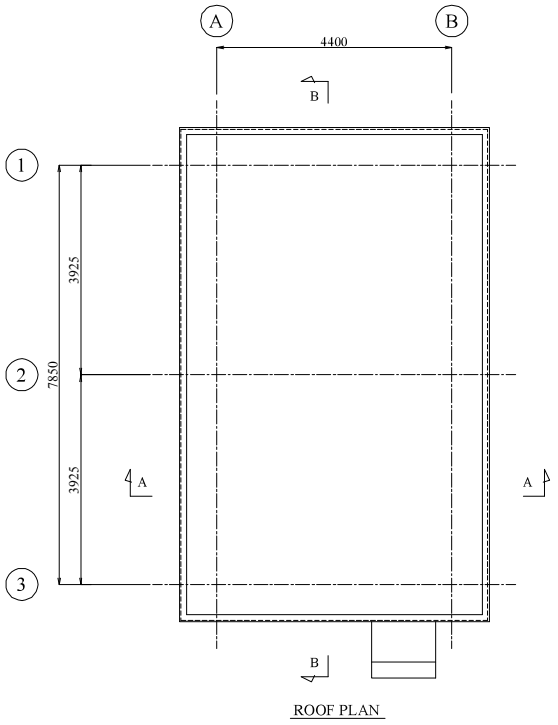

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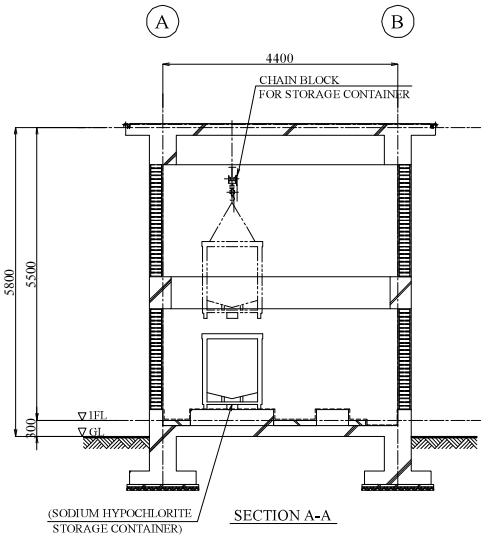

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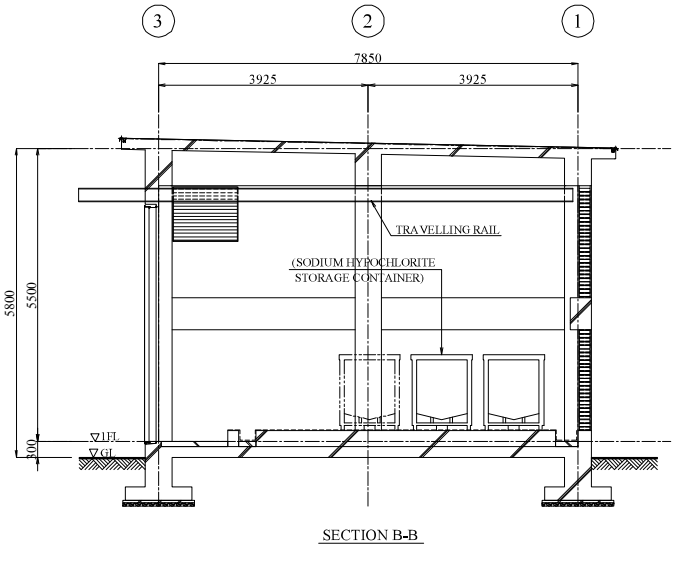

SECTION B-B

REMARKS :	THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN MANDALAY CITY	MANDALAY CITY DEVELOPMENT COMMITTEE (MCDC) THE REPUBLIC OF THE UNION MYANMAR TEC INTERNATIONAL CO., LTD. JAPAN	TITLE : General plan and structure of disinfection facility in No.2 elevated tank	SCALE : 1:600, 1:100 DRAWING NO. : 22	APPROVED BY : PREPARED BY : DATE : OCTOBER 2014

2－2－4. Implementation Plan

2－2－4－1. Implementation Policy

This plan will be implemented according to the framework of the Japanese grant aid cooperation scheme. The Project implementation will be approved by both governments and the Project will be implemented after the Exchange of Notes between the two governments. Subsequently, an agreement will be made between MCDC, the implementing organization of the Myanmar government, and by the Japanese consultant, after which the detail design, construction and supervision will start.

The construction plan and procurement for the cooperation project will be formulated with paying attention to the basic policy described below, considering contents of construction of facilities and the framework of grant aid cooperation.

(1) Project implementing organization

The Mandalay City Development Committee (MCDC) is the organization responsible for supervision and implementing the Project in Myanmar. The Department of Water and Sanitation in MCDC will be responsible for the water supply, sewerage and sanitation work.

(2) Consultant

To construct the facilities planned, the Japanese consultant will conclude an agreement with the implementing organization of Myanmar, and carry out the detail design and construction supervision. The consultant will select a contractor through tender, in which the consultant will prepare tender documents and support the organization for pre-qualification and tender related work. After the construction of the facilities starts, the consultant will supervise construction work objectively and implementation of grant aid fund adequately.

(3) Contractor for construction and procurement

Japanese contractors selected through tender will perform construction of facilities and procure materials related to the Project according to the framework of the Japanese grant aid cooperation scheme. Since the facilities will be constructed and the materials and equipment will be procured at a site remote from Japan and under an environment completely different from that of Japan, contractors must have the requisite to complete the work overseas. Moreover, this Project necessitates the use of locally-procured materials and equipment and work in the urban area; therefore, the contractor must be adequately aware of the local market and labor laws,

know the place well, and understand the customs and accepted practices.

Even after completion of the Project, procurement of spare-parts accompanying operation and maintenance, after-care services such as response to accidents, and so on, will be necessary; therefore, even after handing over the facilities, the contractor must ensure an adequate communication system.

2－2－4－2. Implementation Conditions

The rainy season in Mandalay City is usually for six months from May to October. The annual precipitation amount is about 900 mm, and this precipitation is rather small compared to other areas in Myanmar. The site of construction of distribution reservoir has satisfactory soil structure condition and does not need a pile foundation. However, a proper construction plan must be considered paying attention to work at the appropriate period and ensuring that the ground surface does not get disturbed due to precipitation when working with direct foundation. The work of laying pipes will extend over a long period, and the rainy season cannot be avoided. Therefore, drainage plan must be considered at the location of pipe laying during excavation work. The pipes may have to be passed under existing wastewater gutters, so work may have to be performed by avoiding the existing gutters. There is a commercial railway track crossing at one location, but the railway lines are in the shape of a Y; therefore two lines need to be crossed. The plan for laying the pipelines over a 70 m distance between these lines must include trenchless construction by pipe jacking method.

Among the pipe laying routes, the intersection with the Yangon-Mandalay road, the Thar Yar Waddy Min Gyi Street, the No. 62 Street, the Min Gyi Yan Naung Street have considerably large traffic volume; therefore, a traffic diversion plan must be prepared considering safety measures so that vehicles on road and pedestrians are not inconvenienced by the work. Considerations must be given to ensure safety of third party in the city and measures adopted to avoid disturbance in the livelihood of people. Shops and restaurants abound along the pipe laying routes, and the intake well is planned to be constructed within a park; therefore, before the start of work, an explanatory meeting must be held for the residents in the vicinity requesting them to cooperate and efforts must be made to ensure that no hindrance occurs to the work.

The procurement of materials and equipment will be made from Japan, third countries near Myanmar, and Yangon. Therefore, adequate space must be ensured for temporarily storing materials and equipment. The MCDC material yard was checked for availability of space as a candidate storage site, and the results of the study showed that the space available at BPS No. 3 or the BPS No. 6 could be used as a temporary storage site for this work.

2－2－4－3. Scope of Works

The scope of works to be undertaken by Japanese side and by Myanmar side is shown in the table below.

Table 2-21 Demarcation of construction works of facilities between the two countries

Items	Covered by the Grant	Covered by Recipient	Timing
1. To secure land		●	Before consultant agreement
2. To clear, level and reclaim the site when needed		●	Before commencement
3. To construct gates and fences in and around the site		●	Before commencement
4. To construct parking lot	●		After commencement
5. To construct roads			
(1) Within the site	●		After commencement
(2) Outside the site		●	Before commencement
6. To construct the building	●		After contract
7. To provide facilities for the distribution of electricity and water supply			
(1) Electricity			
a. The distributing line to the site		●	After contract
b. The drop wiring and internal wiring within the site	●		After commencement
c. The main circuit breaker and transformer	●		After commencement
(2) Water Supply			
a. The city water distribution main to the site		●	After contract
b. The supply system within the site (receiving and/or elevated tank)	●		After commencement
c. Laying work and procurement of water service equipment			After completion of the Work
(3) Drainage			
a. The drainage main (for storm, sewer and others) to the site		●	After contract
b. The drainage system (for toilet sewer, ordinary waste, storm drainage and others) within the site	●		After commencement
(4) Gas Supply			
a. The city gas main to the site		●	After contract
b. The gas supply system within the site	●		After commencement
(5) Telephone System			
a. The telephone trunk line to the main distribution frame/ panel (MDF) of the building		●	After contract
b. The MDF and the extension after the frame / panel	●		After commencement
(6) Furniture and Equipment			
a. General furniture		●	After contract
b. Project equipment	●		After commencement
8. To bear the following commissions to a bank of Japan for the banking services based on B/A			
(1) Advising commission of A/P		●	After contract
(2) Payment commission		●	After contract
9. To ensure prompt unloading and customs clearance at the port of disembarkation in recipient country			
(1) Marine (Air) transportation of the products from Japan to the recipient country	●		As required after commencement
(2) Tax exemption and customs clearance of the products at the port of disembarkation		●	As required after commencement

Items	Covered by the Grant	Covered by Recipient	Timing
(3) Internal transportation from the port of disembarkation to the Project site	●		As required after commencement
10. To accord Japanese nationals whose services 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		●	After contract
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 contract		●	As required after commencement
12. To maintain and use properly and effectively the facilities constructed and equipment provided under the Grant Aid		●	After handing over
13. To bear all the expenses, other than those to be borne by the Grant Aid, necessary for construction of the facilities as well as for the transportation and installation of the equipment		●	As required after commencement
14. To appoint counterpart personnel to implement the Project		●	As required after commencement

"Before commencement": Before commencement of the work, "After commencement": After commencement of the work, "After contract": After conclusion of the Contract between MCDC and Contractor, "After handing over": After handing over of facilities and equipment

2－2－4－4. Consultant Supervision

This Project will be implemented under Japan's grant aid cooperation scheme, and the consultant will be responsible for preparing the detail design, supervising construction procuring equipment, and performing soft component activities.

(1) Detailed Design

The consultant will carry out the detail design and prepare tender drawings and all documents required for implementing the Project. The consultant will promote MCDC to confirm willingness to install house connection for residents and proceed application process for house connections through the soft component and the number of house connections must be fixed through survey to be undertaken during the detail design.

(2) Tendering

The consultant will assist MCDC to ensure that the tender is executed fairly and smoothly.

(3) Construction Supervision

The consultant will support MCDC to hold discussions before start of work, to inspect the materials and equipment' factory, to attend to transport of materials and equipment on site, to inspect work and installation of equipment, to conduct trial operation, to provide guidance and

supervise construction workers with the focus on quality control and processes related to completion of inspections, and to ensure that the work is completed within the period defined in the G/A. The consultant will also conduct soft component activities during the work period, and provide technical support for operation and maintenance of the facilities.

2－2－4－5. Quality Control Plan

(1) General items for quality control of construction work

Resident supervisor shall prepare construction supervision procedures based on the quality control plan. Quality control, progress control, and safety and environmental control will be implemented according to this plan. The main items of quality control for the work on site are given below.

- Concrete: Material tests (aggregate and cement), test mix proportion, strength tests, slump tests
- Reinforcement: Tensile and bending tests (factory shipment certificate)
- Premises pipelines and distribution pipelines: Water pressure tests
- Pavement base and pavement: Material tests, density tests, asphalt tests, etc.
- Mechanical equipment: Installation inspection, actual loaded operation test
- Electric equipment: Measurement of insulation resistance, sequence interlock tests

(2) Quality control of wells

1) Pumping test for single well

This pumping test consists of step-drawdown test (10 hours (1 step = 2 hours with 5 steps)), and continuous pumping test (24 hours) and recovery test (12 hours). In step-drawdown test, well loss coefficient and well efficiency will be estimated and the rate of well loss in drawdown will be studied. The main purpose of continuous pumping test is to estimate drawdown by estimating various hydraulic constants and to understand recovery condition of water level by recovery test.

2) Pumping test for multiple wells

To conduct pumping test for multiple wells, pumping of water starts in three (3) wells constructed in this Project at same timing and variation of groundwater level is observed in three (3) wells and observation well. The period of test is 24 hours and recovery test is conducted right after shut down of pumping and variation of groundwater level is again observed until groundwater recovers to static water level. The pump discharge is determined by the result of pumping test for single well.

3) Success criteria of well

a) Success criteria of single well

Success criteria of single well depends on whether 50 L/min. and 3,000 m^3/d (Operation hours is assumed as 17 hours.) could be pumped from the well or not. (As described later, even if pumping rate of single well is slightly less than 3,000m^3/d but if 9,000 m^3/d in total of 3 wells can be pumped up, it may be judged that well is successful.)

Well loss coefficient and well efficiency will be estimated from step-drawdown test and if drawdown of groundwater level causes well loss significantly, it is judged that well is unsuccessful because of probable defect in well completion even if above volume can be pumped up.

b) Success criteria of multiple wells

If more than 9,000m^3/d with17 hours pump operation is possible and it doesn't have an effect on intake condition of the existing wells in BPS No.7 (PTW35 and PTW36)[10], it is judged that multiple wells are successful. If more than 9,000m^3/d with17 hours pump operation is not possible and it has an effect on intake condition of the existing wells in BPS No.7 (PTW35 and PTW36), pumping rate of single well will be reduced and the number of wells will be increased.

c) Water quality test

Water quality test is conducted for physic-chemistry items. The following items shall be confirmed based on MCDC's regular measurement items for water supply system. The judgement is made based on the MCDC's standards.

Table 2-22 MCDC Drinking water quality standards

Item (Unit)	(Maximum/Range) Desirable value	(Maximum/Range) Allowable value
pH	7.0 – 8.5	6.5 – 9.2
Color (Units)	5	50
Turbidity (NTU)	5	25
Ca (mg/L)	75	200
Mg (mg/L)	30	150
Total hardness (mg/L as $CaCO_3$)	100	500
Chloride (mg/L)	200	600
Sulfide (mg/L)	200	400
Fe (mg/L)	0.1	1.0
Mn (mg/L)	0.05	0.5

[10] According to the result of pumping test for single well and multiple wells, supervisor recalculates and forecast long term drawdown of groundwater including at point of the existing wells. It will be judged whether there is effect on well intake or not based on the relation between the forecasted result and the existing well's facilities (groundwater level and pump location).

In addition to the MCDC's standards, fluorine is measured. The WHO guidelines for drinking-water quality, 4th edition are used for the judgment criterion in terms of fluorine, which is set as less than 1.5mg/L.

(3) Quality control of monitoring system

With regard to quality control of monitoring system, in addition to the factory acceptance test, site acceptance test will be conducted after delivery and installation, and it shall be confirm whether system is activated well or not.

2－2－4－6. Procurement Plan

Materials and equipment for the Project will be procured from Japan and third countries. The following table shows the scheduled procurement locations in case of various materials and equipment.

Table 2-23 Procurement plan of materials and equipment

Items	Myanmar	Japan	Third country
Cement	○		
Aggregate	○		
Reinforcing bar	○		
Fuel (Gasoline and diesel)	○		
Mold form	○		
Ductile iron pipe		○	○
u-PVC pipe	○	○	○
HDPE pipe	○	○	○
Coated steel pipe		○	○
Valve		○	○
Water meter		○	○
Base course material	○		
Asphalt pavement material	○		
Framework and support material	○		
Temporary work material (sheet pile and earth retaining material)		○	○
Mechanical material		○	○
Sodium hypochlorite generation unit		○	○
Dosing pump of sodium hypochlorite and storage tank		○	○
Electrical equipment (Electrical panel)		○	○
Instrument equipment for monitoring system		○	○

In case of procurement from Japan or a third country, the materials and equipment will be unloaded at Yangon port or Thilawa port and transported over land to the site. Yangon port is located 15 km to the west of Yangon City, while Thilawa port is located on the east coast of the

Yangon River, 25 km to the south of Yangon City. Thilawa port is an international port newly established in Thilawa district. Compared to Yangon port, the convenience of use of equipment is higher at Thilawa port and large ships can enter the port; therefore, materials and equipment for work are mainly unloaded at Thilawa port. About one week is required for completing customs formalities at Thilawa port. The overland distance from Thilawa port to the storage destination of materials and equipment for the work in Mandalay City is about 700 km.

2－2－4－7. Operational Guidance Plan

The construction company will provide initial operational guidance and operating instructions related to the facilities constructed. Operational guidance will be provided based on the manuals in English before handing over the facilities. Trials and adjustments of pumping system and distribution monitoring system will be carried out after their installation. The engineer of the construction company will give operational guidance. Items required for operational guidance and operation of each facility are given in the table below.

Table 2-24　Contents of initial operation and operation guidance

Facility name	Contents
Water supply facility in Pyi Gyi Tagon TS (Intake well, distribution pump, DMAs and house connection pipe)	・ Operation of intake well pump and distribution pump (normal condition and emergency) ・ Intake well pump, valves related to distribution pump, instrument equipment (water level and water flow etc.) and handling method of ancillary equipment of electrical panel ・ Pumping test for multiple wells[1)] ・ Inspection and repair method of mechanical equipment (pump equipment and valve, etc.) ・ Inspection and repair method of electrical equipment (pump panel, console panel and transformer, etc.) ・ Inspection and repair method of instrument equipment (water level and water flow, etc.) ・ Inspection and repair method of distribution monitoring equipment ・ Maintenance method (inspection, maintenance and repair) of valves (Gate valve, air valve and washout valve) ・ Installation method of house connection
Chlorination facility	・ Operation of generation equipment of sodium hypochlorite and dosing equipment (normal condition and emergency) ・ Inspection, maintenance and repair of generation equipment of sodium hypochlorite and dosing equipment ・ Calculation of dosing rate and measurement method of residual chlorine

1): Detail of specification of pumping test for multiple wells is instructed by supervisor based on the result of pumping test for single well (In principal, continuous pumping test (24 hours) and recovery test up to static water level) The Contractor control pumping rate, observe groundwater level, and report the result to the supervisor.

2－2－4－8. Soft Component (Technical Assistance) Plan

(1) Necessity of soft component

For groundwater usage equipment such as wells, which will be constructed in the Project, MCDC has comparatively adequate knowledge on operation and maintenance. An assistance for operation and maintenance of disinfection facility is being given presently under the Japan's grassroots technical cooperation project, "Project for improving water treatment plant operation and management capacity in Mandalay City (January 2014 to December 2016)." On the other hand, technology transfer through soft components is considered necessary for ensuring realization of project effects and sustainability of the Project with respect to the points mentioned below.

1) Distribution management

Until now, MCDC has not accumulated basic data such as distribution amount and distribution pressure of the service areas, which have been estimated from the capacity of the distribution facilities. The reliability of this data is, however, low and the distribution amount and non-revenue water ratio in distribution area are unknown. Therefore, the water distribution status is not known, and operation and maintenance of distribution facilities is inappropriate; so distribution management cannot be performed properly.

The distribution pipeline network in the new water supply system of this Project will be divided by DMA, a monitoring system will be installed in each DMA and basic data will be collected; in this way, basic data necessary for distribution management will be acquired for the first time. However, the knowledge of the staff and technical levels of the Water Supply and Sanitation Department of MCDC presently are inadequate, and an assistance is necessary for improving skills related to distribution management through soft component.

2) Ensuring new connections for customers

One of the Project's components is the provision of new water supply facilities for un-served areas. There is concern that residents of un-served areas who have been using private wells free of charge may resist paying water tariff for new water connections. For this reason, it is important to deepen the understanding of the residents on the direct and indirect benefits and value of the water supply services through enlightenment and diffusion activities for the residents.

3) Strengthening groundwater monitoring systems and using observation results

The reasons why MCDC has not implemented groundwater monitoring (groundwater level

observations) area as follows

a) Production wells do not have a structure, by which groundwater level is easily observed.

b) There is no observation well and selection of alternative wells is not adequate.

For the countermeasure, observation well will be constructed and production well has structure which can observe groundwater level around BPS No.7 in the Project.

Through continuous monitoring activities of groundwater by setting up the specifications of monitoring activities, groundwater level management is required.

The Project will provide three new production wells near the BPS No. 7. MCDC already has two production wells in the premises of BPS No. 7; so it will have a well field consisting of five wells in total.

The drawdown in the groundwater level will be estimated for planning the groundwater development mentioned above. The estimate may be made using theoretical equations based on the pumping test results of the test-bored well. For analysis with higher accuracy and for appropriate management and operation of each well in the well field, groundwater data must be collected..

Moreover, it is necessary to establish a system to make periodical observation, by selecting existing wells for monitoring water level near production wells, in the soft component.

In addition, it is necessary to propose an overall monitoring system in the entire city area to understand groundwater level in the city, in soft component

(2) Goal of soft component

The staff members of MCDC shall acquire knowledge and skills necessary for: 1) distribution management; 2) Public awareness and dissemination; and 3) strengthening the groundwater level monitoring system and appropriate use of observation results. Through these activities, capacity of MCDC staff on continuous operation and maintenance of water supply system will be enhanced.

(3) Outcome of soft component

The outcomes of the implementation of soft component are given below.

Outcome 1: Distribution management skills are enhanced.

Outcome 2: Skills in public awareness and dissemination are enhanced.

Outcome 3: Groundwater management skills are enhanced.

(4) Confirmation of achievement level

The method of confirming achievement level is shown in the table below.

Table 2-25 Confirmation of achievement

Outcomes	Description	Items for confirming achievement level	Training method
1. Distribution management skills are enhanced.	The status of hydraulics of the distribution system can be understood.	- Is there awareness on the importance of monitoring status considering operation and maintenance? - Can the distribution data required in the pilot areas[*1] be properly collected, tabulated, analyzed and charted? - Can the tabulated results of the pilot areas be properly interpreted?	Record of training and practice implementation Paper test (data analysis)
	Distribution data is used for managing distributed water (including non-revenue water management).	- Can non-revenue water be estimated after comparing distributed water data and metered water quantity (quantity on water meter) in the pilot areas? - Has the distribution method meeting intake water flow been set up?	Record of training and practice implementation Paper test (data analysis)
	Manuals related to the activities mentioned above are available.	- Have manuals for distribution management been prepared?	Confirmation of existence of distribution management manuals
2. Skills in public awareness and dissemination are enhanced.	Systems are constructed to promote public awareness and dissemination activities.	- Has the implementing organization constructed a system to promote public awareness and dissemination activities? - Has the implementing organization held explanatory meetings in the project wards? - Have the understanding and awareness of hygiene of the residents related to water supply system and services improved?	Confirmation of the result of staff selection Confirmation of holding of explanation meeting in the Project target area (ward) Confirmation of the result of questionnaire after explanation meeting
	Guidelines related to the above activities have been provided.	- Have public awareness and dissemination activity guidelines been prepared?	Confirmation of existence of public awareness and dissemination activity guidelines
3. Groundwater management skills are enhanced.	Techniques for observing, processing and analyzing groundwater levels have been acquired.	- Has an observation field book or ledger been prepared for groundwater level observations? - Can the accuracy of observation records be confirmed? - Can a record of changes in groundwater levels be prepared? - Can the distribution of groundwater levels be understood?	Record of training and practice implementation Paper test (data analysis)
	Intake amount depending on	- Has the method of analyzing pumping test been understood?	Record of training

Outcomes	Description	Items for confirming achievement level	Training method
	groundwater variety has been set up	- Has water level prediction analysis using hydraulics formula been understood? - Has the relationship between pumped volume and groundwater level change been understood? - Has intake water flow been set accounting to change of groundwater level	and practice implementation Paper test (data analysis)
	Manuals on the above-mentioned activities have been provided.	- Have manuals on groundwater level monitoring and pumped water management been prepared?	Confirmation of existence of manuals for groundwater level monitoring and capacity management of pumping up

*1: A DMA, in which house connection work has been completed, will be selected as a pilot area, and training program will be formulated. DMA has been set for each of the five administrative divisions, namely Wards 2, 4, 5, 6, and 10. One of these wards will be selected as pilot area.

(5) Soft component activities (input plan)

Outcomes		Activity
1	Distribution management skills are enhanced.	Preparation of manuals, implementation of training related to use of data in management and analysis of distribution data, distribution management (including non-revenue water management)
2	Skills in public awareness and dissemination are enhanced.	Training in public awareness and dissemination activities, assistance in implementation (holding explanatory meetings with residents, visits to individual households, etc.) and preparation of guidelines
3	Groundwater management skills are enhanced.	Groundwater level observation techniques (portable water level gauge, automatic water level gauge), implementation of training methods for managing pumped water using groundwater level data, preparation of manuals, etc.

Detailed description of soft component activities (Input plan) is given in the table below.

Table 2-26 Input plan of [Outcome 1]

No.	Activity	Input	
		Japanese Side	No. of participants on the Myanmar side
1)	Preparation for training		
①	Domestic preparation (Distribution management expert)		
D-1	Preparation of transfer of technology plan	1 person × 1 day＝1 person-days	—
D-2	Preparation of test, questionnaire, training text (draft)	1 person×4 day＝ 4person-days	—
	Travel	1 person×1 day＝1	—

No.	Activity	Input	
		Japanese Side	No. of participants on the Myanmar side
		person-day	
②	Preparation of training and introductory technical briefing (Distribution management engineer)		
②-1	Preparation of training room, C/P meeting, Preparation of implementation and briefing	1 person×4 days＝4 person-days	2 persons×4 days＝8 person-days Chief engineer and head of distribution section
②-2	Selection of trainees (pre-test, questionnaire, evaluation, selection)	1 person×3 days＝3 person-days	2person×3 day＝6 person-days
②-3	Implementation of briefing	1 person×1 day＝1 person-days	20 persons×1 day＝20 person-days MCDC Dept. of Water and Sanitation 13 persons, 1 person from each 5 DMAs and 2 persons from township
Sub-total		**14 person-days**	**34 person-days**
2)	Distribution data management (Distribution management engineer)		
①	Data analysis and data utilization		
①-1	Explanation on purpose and method of collection distribution data, outline of equipment, normal and abnormal value (flow meter, water pressure gauge (lecture))	1person×2 day＝2 person-days	9persons×2 day＝18 person-days MCDC Dept. of Water and Sanitation 4 person, 1 person from 5 DMAs
①-2	Collection of distribution data (Explanation on the collection method of flow data transmitting to monitoring equipment and the data capture method (lecture and workshop))	1 person×3 days＝3 person-days	9 persons×3 days＝27 person-days
①-3	Analysis of distribution data in the pilot areas (Analysis and evaluation of the collected data on time, date, seasonal variation of water quantity and quality (lecture and workshop))	1person×2 days＝2 person-days	9 persons×2 days＝18 person-days
Sub-total		**7 person-days**	**63 person-days**
3)	Distribution management (Distribution management engineer)		
①	Data utilization for water distribution management and non-revenue water management (Explanation on the management method of flow volume and water pressure in the pilot areas, Identification of non-revenue water amount and the causal analysis in comparison to revenue data collected	1 person×5 days＝5 person-days	9 person×5 days＝45 person-days
Sub-total		**5 person-days**	**45 person-days**
4)	Preparation for manuals relevant to the abovementioned activities		
①	Preparation for a manual of distribution management	1 person×2days＝2 person-days	2 persons×2 days＝4 person-days
Sub-total		**2 person-days**	**4 person-days**
5)	General report (Distribution management engineer)		

No.	Activity	Input	
		Japanese Side	No. of participants on the Myanmar side
①	General seminar		
①-1	Preparation for general seminar	1 person×2 days＝2 person-days	9 person×2 day＝18 person-days
①-2	Holding seminar	1 person×1 day＝1 person-day	20 person×1 day＝20 person-days
②	Preparation for report		
②-1	Soft component evaluation	1 person×1 day＝1 per son-day	—
②-2	Preparation and submission of general report	1 person×1 day＝1 person-day	—
Sub-total		**5 person-days**	**38 person-days**
	Travel	**1 person-days**	—
Total		**34 person-days**	**184 person-days**

[Note] the desirable number of participants and the name of department/section from the Myanmar side is assumed by JICA Study Team

Table 2-27 Input plan of [Outcome 2]

No.	Activity	Input	
		Japanese Side	No. of participants on the Myanmar side
1)	Preparation		
①	Domestic preparation (Institutional development/ public awareness and dissemination activity expert)		
D-1	Preparation of transfer of technology plan	1 person×1 day＝1 person-day	—
D-2	Preparation of questionnaire, training text(draft), Handout for residential meetings	1 person×4 day＝4 person-days	—
	Travel (1st fieldwork)	1 person×1 day＝1 person-day	—
2)	Assistance for institutional development for the enhancement of public awareness and dissemination activity		
①	Assistance for institutional development		
①-1	C/P meeting, Selection of the responsible staffs, Consideration of the support system	1 person×5 days＝5 person-days	2 persons×5 days＝10 person-days, Chief engineer and Revenue section
①-2	Meeting with the responsible staffs, Development of public awareness and dissemination activity plan	1 person×5 days＝5 person-days	2 persons×5 days＝ 10person-days
	Sub-total	**16 person-days**	**20 person-days**
3)	Enhancement of public awareness and dissemination activity for residential people		
①-1	Preparation of explanatory meeting for residential people, Coordination (C/P, TS offices), Preparation of handout and materials	1 person×7 days＝7 person-days	5 persons×7 days＝35 person-days, Revenue section 5 persons
①-2	Holding explanatory meeting for residential people (all 5 TSs)	1 person×5 days＝5 person-days	5 persons×5 days＝25 person-days
4)	Enhancement of new service agreements for new customers		

No.	Activity	Input	
		Japanese Side	No. of participants on the Myanmar side
①-1	Enhancement of new service agreements by visiting individual household	1 person×6 days＝6 person-days	5 persons×6 days＝30 person-days
	Travel	1 person×1 day＝1 person-day	—
	Sub-total	**19 person-days**	**90 person-days**
	Travel (2nd fieldwork)	1 person×1 day＝1 person-day	—
5)	Monitoring of public awareness and dissemination activity for residential people		
①-1	Monitoring the progress of new service agreement for new customers and follow-up	1 person×10 days＝10 person-days	5 persons×10 days＝50 person-days
	Sub-total	**11 person-days**	**50 person-days**
6)	Preparation of the Guideline related to the above activity		
	Preparation of the Guideline for public awareness and dissemination activity	1 person×2 day＝2 person-days	2 persons×2 days＝4 person-days, Revenue collection section 2 person
Sub-total		**2 person-days**	**4 person-days**
7)	General report (public awareness and dissemination for residential people)		
①	General seminar		
①-1	Preparation for general seminar	1 person×2 days＝2 person-days	2 persons×2 days＝4 person-days
①-2	General seminar	1 person×1 day＝1 person-day	2 person×1 days＝2 person-days
②	Preparation for final report		
②-1	Soft component evaluation	1 person×1 day＝1 person-day	—
②-2	Preparation and submission of general report	1 person×1 day＝1 person-day	—
	Sub-total	**5 person-days**	**6 person-days**
	Travel	**1 person-days**	—
Total		**54 person-days**	**170 person-days**

[Note] the desirable number of participants and the name of department/section from the Myanmar side is assumed by JICA Study Team

Table 2-28 Input plan of [Outcome 3]

No.	Activity	Introduction	
		Japanese Side	No. of participants on the Myanmar side
1)	Preparation		
①	Domestic preparation (Groundwater management expert)		
D-1	Preparation of transfer of technology plan	1 person×1 day＝1 person-day	—
D-2	Preparation of questionnaire, training text(draft), Handout for residential meetings	1 person×4 days＝4 person-days	—
	Travel	1 person×1 day＝1 person-day	—

No.	Activity	Introduction	
		Japanese Side	No. of participants on the Myanmar side
2)	Acquisition of observation technique for groundwater level		
①-1	To implement basic lecture for observation of groundwater and observation well	1 person×1 day＝1 person-day	10 persons×1 day＝10 person-days 2 persons from Dept. of water and sanitation, 8 persons of operators from section of well/electricity/mechanic facilities in MCDC
①-2	To obtain the method of water level measurement by using potable water level gauge and database preparation	1 person×1 day＝1 person-day	10 persons×1 day＝10 person-days
①-3	To obtain the method of data preparation of recording water level gauge	1 person×1 day＝1 person-day	10 persons×1 day＝10 person-days
①-4	To obtain the calculation method of the fluctuating groundwater level and analysis method	1 person×1 day＝1 person-day	10 persons×1 day＝10 person-days
①-5	To obtain the preparation method of groundwater level distribution and analysis method	1 person×1 day＝1 person-day	10 persons×1 day＝10 person-days
	Sub-total	**11 person-days**	**50 person-days**
3)	To obtain the management method of pump discharge amount by using groundwater level data		
①-1	To obtain the calculation method of fluctuating groundwater level and the analysis method of pumping test	1 person×2 days＝2 person-days	10 persons×2 day＝20 person-days
①-2	To obtain the management method of pump discharge amount by using the forecast calculated water level and actual measured water level	1 person×2 days＝2 person-days	10 persons×2 day＝20 person-days
	Sub-total	**4 person-days**	**40 person-days**
4)	Preparation of manual related to the above activities		
①-1	Preparation of manuals for groundwater monitoring and pump discharge amount management	1 person×2 days＝2 person-days	2 persons×2 days＝4 person-days
	Sub-total	**2 person-days**	**4 person-days**
5)	General seminar		
①	General seminar		
①-1	Preparation of general seminar	1 person×2 days＝2 person-days	2 persons×2 days＝4 person-days
①-2	General seminar	1 person×1 day＝1 person-day	2 persons×1 day＝2 person-days
②	Preparation for report		
②-1	Soft component evaluation	1 person×1 day＝1 person-day	—
②-2	Preparation and submission of general report	1 person×1 day＝1 person-day	—
	Sub-total	**5 person-days**	**6 person-days**
	Travel	**1 person-days**	—
Total		**23 person-days**	**100 person-days**

[Note] the desirable number of participants and the name of department/section from the Myanmar side is assumed by JICA Study Team

(6) Procurement method of implementation resources of soft component

As soft component, the three Japanese consultants mentioned below will be dispatched to the site. The use of Japanese consultants on site is deemed appropriate judging from the need and conditions mentioned below. Therefore, the soft component will be implemented as direct assistance.

1) Distribution management expert

One Japanese consultant well versed in distribution management will be dispatched.

This expert is required to be knowledgeable in hydraulics, possess experience related to formulating the distribution management plan and language skills to communicate with engineers in Myanmar, in addition to the ability to understand issues on operation and maintenance of distribution systems in developing countries.

This soft component will be implemented after the work designed by Japanese consultants and a series of main tasks such as work supervision are completed; therefore, it is appropriate that the Japanese expert who understands the specific technology through the planning and construction work stages of this Project implement this soft component.

2) Institutional development and public awareness and dissemination activity expert

Since there is no section in the Department of Water and Sanitation in charge of promoting and diffusing water supply activities, there is no foundation. The staff member responsible for promoting public awareness and dissemination activities to residents will be selected from the staff of the Department of Water and Sanitation. The consultant will support the maintenance of the system so that organizational approach can be adopted. The consultant will give assistance to the staff member in charge of public awareness and dissemination activities so that the said member can appropriately promote public awareness and dissemination activities to diffuse and promote the new water supply system to be constructed under the Project. This refers to the assistance to promote and ensure new house connections. The consultant will support the staff member in building up the awareness of the importance of customer-related management by preparing the public awareness and dissemination activity plan, by holding explanatory meetings, and by individual visits. The consultant will assist in the startup of activities to promote new house connections, monitor the results after a fixed period of time, and follow-up on the same for improvement. A direct assistance is necessary for promoting the development of business services focusing specially on customers in the future and for implementing public awareness activities, by which benefits of water supply service is disseminated as much as possible.

This soft component is to be implemented from the time of the detail design stage. Institutional development and public awareness and dissemination activity expert needs to share

information on the outline of waterworks, specific technology of house connections, project implementation and supervising work with Japanese consultant who conduct field survey for the detail design; therefore, it is appropriate that the Japanese expert implements this soft component.

3) Groundwater management expert

One Japanese consultant well versed in groundwater management will be dispatched.

This expert will be required to possess knowledge on hydrogeology, experience in drilling of wells and other items related to groundwater development, language skills to communicate with the engineers of Myanmar, and the ability to understand issues on operation and maintenance of the groundwater system in developing countries.

This soft component is to be implemented after the work designed by Japanese consultants and after a series of main tasks such as work supervision are completed; therefore, it is appropriate that the Japanese expert understand the specific technology through the planning and construction work stages of this Project implement this soft component.

Details of personnel dispatch plan are shown in the table below.

Table 2-29 Staff assignment plan

Category	No. of persons	Country	Contents
Distribution management	1	Japan	To apply distribution management technique to the site condition and trainee's technical skills and implement the follwing items ▪ Preparation of training text and implementation of training ▪ Preparation and evaluation of test and report homework ▪ Preparation of manuals ▪ Preparation of several kinds of format ▪ Implementation of seminar ▪ Data collection, editting and modeling ▪ Evaluation
Institutional development/ public awareness and dissemination activity	1	Japan	To apply institutional development/ public awareness and dissemination activity method to the site condition and trainee's technical skills and implement the follwing items ▪ Preparation of public awareness and dissemination action plan ▪ Preparation of material for stakeholder meeting ▪ Implementation of explanatory meetings ▪ Facilitation of the contract by visiting to household ▪ Information and data collection ▪ Evaluation ▪ Meeting with C/P ▪ Preparation of guideline
Groundwater management	1	Japan	To apply groundwater management technique to the site condition and trainee's technical skills and implement the follwing items ▪ Preparation of training text and implementation of training ▪ Preparation and evaluation of test and report homework ▪ Preparation of manuals ▪ Preparation of several kinds of format ▪ Implementation of seminar ▪ Data collection, editting and modeling ▪ Evaluation

(7) Implementation schedule of soft component

1) Distribution data management and distribution management

The soft component requires distribution amounts measured by newly installed monitoring equipment; therefore, such work will start after the construction of facilities is completed. The target location does not cover all the target service areas, but only the DMA for which water supply pipelines have been laid. Such DMA will be set as pilot area and training will be implemented. DMA has been set for each of the five administrative divisions, namely Wards 2, 4, 5, 6, and 10. One of these wards will be selected as a pilot area.

The staff member of MCDC in charge of operating the monitoring system will be trained through OJT by a Japanese contractor in the handling of the equipment before the start of the soft component. The man-days required for soft component are given below.

Actual working days	34 days	Preparation in Japan: 5 days×1 person=5 days/person In the site: 29 days×1 person=29 days/person
Man-Months (MM) converted	In Japan: 0.25MM In the Site: 1.45MM	Preparation in Japan: 0.25MM×1 person＝0.25MM (5 days/20＝0.25MM) Period of dispatch to the site: 1.45MM×1 person＝1.45MM (29 days/20=1.45 MM)

2) Activities for public awareness and dissemination activity

The soft component will be implemented in the period of field survey in the detail survey. Willingness to install house connection of residents will be confirmed before the commencement of the work of the Project and it is necessary to arrange schedule for smooth implementation of laying work of house connection.

Activities for public awareness and dissemination will be divided into two parts. When experts are dispatched the first time, preparations for and assistance in implementing the public awareness and dissemination activities will be carried out; subsequently, MCDC will continue the public awareness and dissemination activities. When the experts are dispatched for the second time, mainly the monitoring of public awareness and dissemination activities taken over by MCDC will be carried out. The timing for dispatch of experts the second time will be about one to two months after the dispatch the first time.

The water service connection laying work is estimated to start the 5^{th} or 6^{th} month after the completion of the manufacture and procurement of water meters after start of the construction work. This work will be implemented after the dispatch of experts the second time and after take-over of public awareness and dissemination activities by MCDC; therefore, the work processes can be implemented sequentially after concluding agreements and contracts related to house connections of the residents.

Actual working days	54 days	Preparation in Japan: 5 days×1 person=5 days/person In the site: 49 days×1 person=49 days/person
Man-Months (MM) converted:	In Japan: 0.25MM In the Site: 2.45MM (1.50+0.95)	Preparation in Japan: 0.25MM×1 person＝0.25MM (5 days/20＝0.25MM) Period of dispatch to the site: (First round): 1.50MM×1 person ＝1.50MM (30 days/20=1.50MM) Period of dispatch to the site: (Second round): 0.90MM×1 person＝0.90MM (19 days/20=0.95MM)

3) Strengthening groundwater monitoring systems and appropriately using the observation results

The soft component will be implemented after the completion of the construction work of wells in this Project. The man-days required for soft component are given below.

Actual working days	23 days	Preparation in Japan: 5 days×1 person=5 days/person In the site: 18 days×1 person=18 days/person
Man-Months (MM) converted:	In Japan: 0.25MM In the Site: 0.90MM	Period of dispatch to the site: 0.25MM×1 person＝0.25MM (5 days/20＝0.25MM) Period of dispatch to the site: 0.90MM×1 person＝0.90MM (18 days/20=0.90MM)

Implementation plan for soft component is shown in the following tables.

Table 2-30 Implementation Plan [Outcome 1]

Activity	1st Month after completion of the Work				2nd Month after completion of the Work			
	Week 1	Week2	Week3	Week4	Week 1	Week2	Week3	Week4
The soft component for distribution management will be started after completion of the Work (33th months after E/N).								
Distribution Management 【Output 1】								
Domestic preparation	■	■						
Preparation for implementation, Seminar for application technology		■	■	■				
1-1. Doistribution data management								
1-1-1. Distribution data analysis and utilization				■	■	■		
1-2. Distribution water management								
1-2-1. Datautilization for distribution managament and Non-Revenuw Water management					■	■	■	
General report (general seminar, preparation and submission of report)						■	■	

Table 2-31 Implementation Plan [Outcome 2]

Activity		1st Month after commencement of detail design				2nd Month after commencement of detail design				3rd Month after commencement of detail design				4th Month after commencement of detail design				5th Month after commencement of detail design			
		Week 1	Week2	Week3	Week4	Week 1	Week2	Week3	Week4	Week 1	Week2	Week3	Week4	Week 1	Week2	Week3	Week4	Week 1	Week2	Week3	Week4
The soft component for enhancement of public awareness and dissemination activity for residential people will be started after one month of commencement of detail design.	Field survey of detail design					Domestic work of detail design															
Enhancement of public awareness and dissemination activity for residential people 【Output 2】 Enhancement of IEC activity for residential people and of the service agreement for new customers																					
Domestic preparation		■	■																		
2-1. Assistance for institutional development for the enhancement of public awareness and dissemination activity																					
2-1-1. Selection of the responsible staffs for public awareness and dissemination activity			■	■																	
2-1-2. Assistance for development of public awareness and dissemination activity plan				■	■																
2-2. Explanatory meetings for residential people (2 townships)																					
2-2-1. Preparation of explanatory meetings for residential people, and coordination					■	■	■														
2-2-2. Implementation of explanatory meetings (each township of the Project area)						■	■	■													
2-3. Enhancement of new service agreements for new customers																					
2-3-1. Enhancement of new service agreements by visiting individual household				1st Fieldwork				■	■	■											
Continuous public awareness and dissemination activities by MCDC		<							>	Public awareness and dissemination activity will be continued by MCDC											
2-4. Monitoring of public awareness and dissemination activity for residential people															2nd Fieldwork		<			>	
2-4-1. Monitoring the progress of new service agreement and follow-up																■	■	■			
General report (general seminar, preparation and submission of report)																			■	■	

Table 2-32 Implementation Plan [Outcome 3]

Activity		1st Month after completion of construction work for intake well			
		Week 1	Week2	Week3	Week4
The soft component for groundwater resource management will be started after completion of construction work for intake well.					
Groundwater resource management	【Output 3】				
	Domestic preparation	■	■		
	3-1. Lecture on basics for monitoring groundwater level and observation wells		■		
	3-2. Water level measurement by using potable water level gauge and database preparation		■		
	3-3. Method of data preparation of recording water level gauge		■		
	3-4. Calculation method of fluctuating groundwater level and analysis		■		
	3-5. Preparation method of fluctuating groundwater level distribution and analysis			■	
	3-6. Management method of pump discharge amount by using the forecast calculated water level and actual measured water level			■	■
	3-7. Management method of pump discharge amount				■
	3-8. Preparation of manuals for groundwater monitoring and pump discharge amount management				■
	General report (general seminar, preparation and submission of report)				■

(8) Outcomes of soft component

The outcomes of soft component are given below.

Deliverables	Submission timing
Soft component plan report	Starting time
Progress report of soft component implementation	Commencement time of activity for outcome 1
Completion report of soft component	Completion time
[Outcome 1] : Distribution data management and distribution management Training material, input distribution data and distribution management manual	Completion time
[Outcome 2] : Activities for informing, educating and communicating with residents Training material, public awareness and dissemination activity plan, PR material, Attendees list of explanatory meeting, customer list of new house connection and public awareness and dissemination activity guideline	Completion time
[Outcome 3] : Strengthening groundwater monitoring systems and appropriately using the observation results Groundwater level monitoring and pumped volume management manual	Completion time

(9) Obligations of the counterpart organizations

1) Responsibility

The responsibility of MCDC for implementation of soft component is as follows.

1. Soft component will be led by MCDC initiative
2. MCDC assigns required staff members (operators and trainees) when required
3. MCDC pays daily allowance and transportation fee to trainees
4. MCDC implements monitoring activities (Water distribution and groundwater management)

2) Probability of implementation

a) Distribution data management and distribution management

The Department of Water and Sanitation of MCDC is aware of the need in future for operation and maintenance after understanding the distribution water quantity and water pressure using monitoring equipment; therefore it has basically ensured the continuity of the work. This awareness is present at the Chief Engineer level and the Distribution Department Head level, that is, at the level of the decision makers. Therefore, the implementation of this component is feasible. This awareness will be adequately shared this time mainly by the trainees, that is, the operation and maintenance staff of the BPS No. 7 and the staff of the wards and staff of the Pyi Gyi Tagon TS.

b) Public awareness and dissemination activity for residents

The Department of Water and Sanitation of MCDC will decide the person in charge, and the top management of the department starting with the Chief Engineer, are adequately aware of the importance of the implementation of this component, so the implementation of this component is feasible.

c) Strengthening groundwater monitoring systems and appropriately using the observation results

The main water source used in the water supply Project this time is groundwater. Since responsible personnel of the MCDC Water Supply and Sanitation Department related to groundwater development are already assigned, all top management members of the department starting with the Chief Engineer are adequately aware of the importance of this component; so the implementation of this component is feasible.

3) Inhibiting factors and countermeasures

Reassignment or transfer of trainees and absence due to often routine work during monitoring and training activities are an inhibiting factor. Measures for holding back this reassignment or transfer of the trainees will be required. If it is difficult to use part of the additional working time by routine work being carried out until now, the senior supervisor should be instructed to assign the trainee as the sole person in charge of managing the monitoring system.

4) Continual approach

a) Distribution data management and distribution management

MCDC must use the data acquired from the monitoring system, consider the content of the same and submit the distribution management report to the decision maker every month to achieve the goal of the soft component.

b) Public awareness and dissemination activity for residents

To achieve the goal of the soft component, the MCDC Department of Water and Sanitation must supervise activities such that the constructed activity system functions properly, cooperate with the TS office, and continuously perform the public awareness activities.

c) Strengthening the groundwater monitoring system and appropriately using the observation results

MCDC must use the data acquired from monitoring activities, consider the content of the same and submit the groundwater management report to the decision maker every month to achieve the goal of the soft component.

2－2－5. Implementation Schedule

The Project is divided into two main components consisting of the construction of water supply system in Pyi Gyi Tagon TS and construction of chlorination facilities. The Project is implemented as a single year budget. The implementation schedule anticipated is shown in figure below.

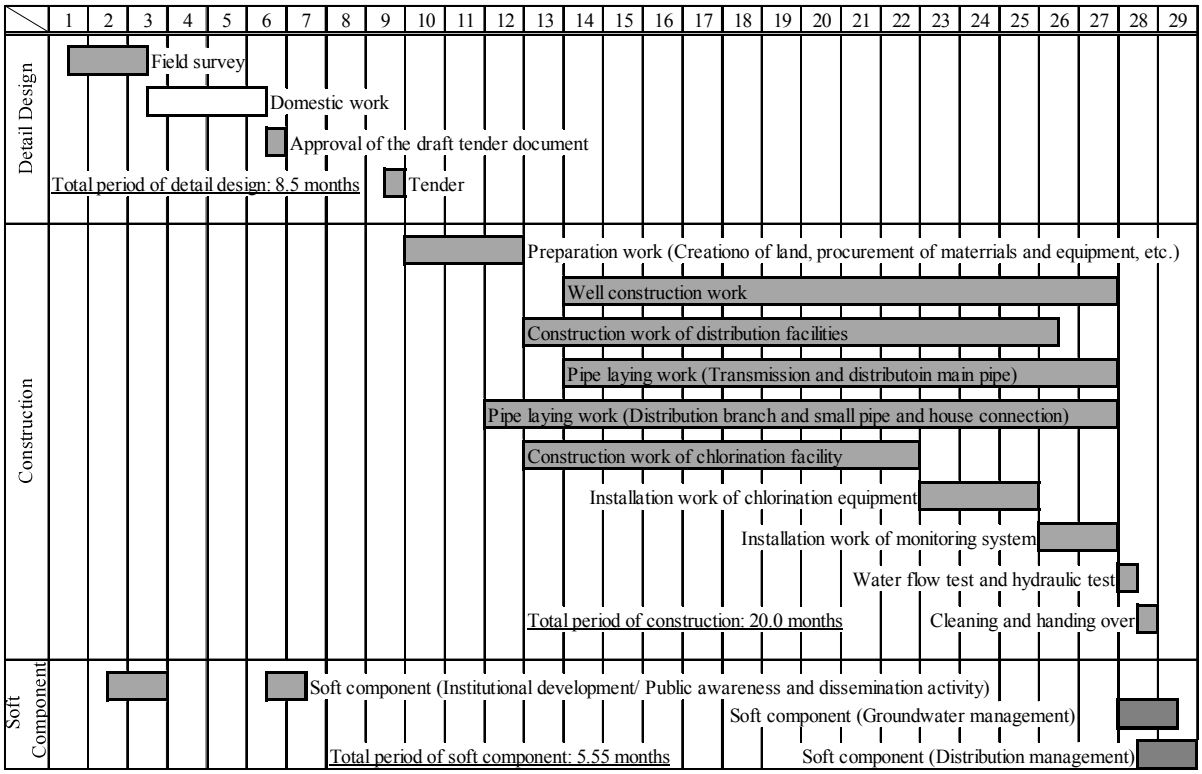

Figure 2-14 Implementation schedule of the Project

2－3. Obligations of Recipient Country

2－3－1. General obligation

General obligations in the scope of Myanmar are as follows:

- To provide data and documents required for the Project
- To secure safety of construction site and provide safety information
- To pay commissions for Banking Arrangement (B/A) and Authorization to pay (A/P)
- To make customs clearance for import of machinery, materials and equipment procured in the Project and re-export of machinery after use in the Project
- To exempt Japanese nationals from custom duties, internal tax and fiscal levies, which may be imposed on procurement of materials and equipment, goods for implementation of service, and sub-contract under the verified contract.
- To afford all other expenses, other than these to be borne by Grant Aid, such as expenses for staff member required for the implementation of the Project

2－3－2. Obligations specific to the Project

The obligations specific to the Project are as follows.

(1) Formalities and acquisition of permits

Formalities and permits to be acquired by the Myanmar side required before and during implementation of the Project include checks on the recent status of formalities of environmental and social considerations being formulated by the Myanmar government, acquisition of permits to use sites for well construction, acquisition of permits for the use of storage sites for materials and equipment in the Pyi Gyi Tagon TS (MCDC site) and the site in BPS No. 7, acquisition of permit to use relevant communications for monitoring systems, MCDC in-house formalities related to use of public roads in the Pyi Gyi Tagon TS and notifications to the police and the relevant bureaus within MCDC (Department of Engineering (Water and Sanitation) and (Roads)) related to traffic regulations and road possession.

The relevant departments and organizations for submitting applications to and for acquiring various permits are listed below.

Table 2-33 Relevant departments and organizations for submitting applications to and for acquiring various permits

Permits and applications necessary for this Project	MCDC-related department or other organization
Checks on latest conditions of formalities for environmental and social considerations presently being formulated by the Myanmar government	Ministry of Environment Conservation and Forestry
Acquisition of permit for using sites for well construction	MCDC Plaza and Horticultural Bureau and MCDC Urban Planning Bureau
Acquisition of permit for use of storage sites for materials and equipment in the Pyi Gyi Tagon TS (MCDC site) and the BPS No. 7 site	MCDC Department of Engineering (Water and Sanitation) and MCDC Plaza and Horticultural Bureau
Application for the use of communications for monitoring systems	Myanmar Post and Telecommunication (MPT) and two private companies (TELENOR and OOREDOO)
MCDC in-house formalities related to use of public roads in Pyi Gyi Tagon TS and acquisition of permits related to traffic regulations and possession of roads	MCDC Department of Water and Sanitation, and MCDC Department of Roads and Police

The acquisition of permits mentioned above is the minimum required formalities for starting the construction of facilities. The JICA Study Team and the MCDC Department of Engineering (Water and Sanitation) understand this need; therefore, the feasibility of implementation is considered to be high.

(2) Power supply

The scope of the Japanese side and the Myanmar side is set as shown in the figure below for power supply to disinfection facilities within the BPS No.1 site, distribution reservoir equipment, water intake equipment in the Pyi Gyi Tagon TS water supply facilities and disinfection facilities of BPS No. 7. The Myanmar side will take the electric cables from the nearest electric pole to the site of the water supply facilities, install the transformers, power meters and circuit breakers. The Japanese side will install equipment such as power cables from the secondary side of the circuit breakers.

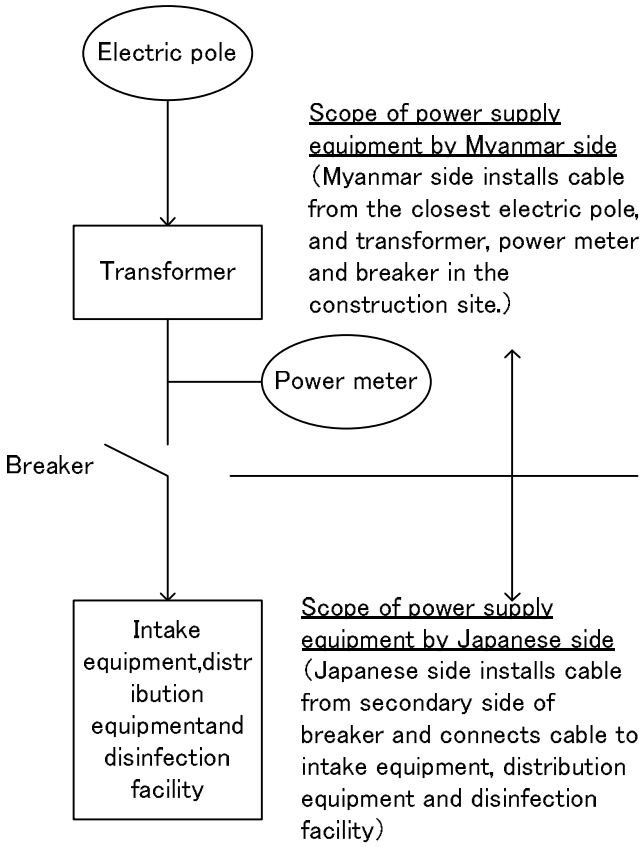

Figure 2-15 Scope of work by the Japanese side and the Myanmar side related to power supply

The power supply equipment required and their specifications were discussed by the staff in charge of electric equipment of the MCDC Department of Engineering (Water and Sanitation) and the JICA Study Team, and the items were determined as shown below. The cost for installing the equipment is calculated by the MCDC Department of Water and Sanitation.

Table 2-34 Power supply equipment required for the Project and approximate expenditure

Facility	Specifications	Qty.	Cost (Kyat)	Total (Kyat)
Wells (3)	100 kVA	3	20,000,000	60,000,000
BPS No.1	315 kVA	1	32,200,000	32,200,000
BPS No.7	400 kVA	1	36,000,000	36,000,000
Total (Kyat)				128,200,000
Total (JPY)				14,358,400

The staff in charge of electric equipment in the MCDC Department of Engineering (Water and Sanitation) and the JICA Study Team will perform checks related to procurement of equipment and installation on site. Since the calculation and budgeting of the expenses for equipment have been made by MCDC the feasibility of implementation, is judged to be high.

(3) House connection

Procurement of materials and equipment and construction of house connections are included in the components of this Project. Residents who desire to have connection must conclude a house connection agreement with MCDC; activities to promote such agreements will be implemented by MCDC. Support for these promotion activities will be through soft component. MCDC has to obtain the land use approval from the land owner of each household before starting the pipe laying work for house connection and undergo the necessary formalities.

As mentioned in "2-2-2-2 Equipment Plan," materials and equipment for house connection will be procured through grant aid cooperation. The number of installation work of house connections to be implemented by the Myanmar side has also been set. This work must be performed by MCDC. Plans will be prepared such that the construction company implements On-the-Job training (OJT) for connecting service pipe during the construction of facilities so as to ensure work quality by MCDC.

By offering support through OJT and soft component as mentioned above for the items to be implemented by MCDC for house connections, the feasibility of implementation can be increased.

(4) Soft component

MCDC must designate staff for participating in the support activities shown in "2-2-4-8 Soft component plan" and must provide daily allowance and transport allowance to the participating staff. Such actions are very important to promote participation by staff members when implementing soft component. These have been agreed with MCDC and are likely to be implemented without any issue.

(5) Others

Other items to be implemented specific to the Project by the Myanmar side include monitoring of groundwater level in observation wells and increase in the employment of water meter readers and tariff collectors after the Project is completed.

2－4. Project Operation and Maintenance Plan

2－4－1. Basic principle for operation and maintenance

Basic policies for operation and maintenance (O&M) of planned facilities are listed as follows.

- New intake wells, new reservoirs and new distribution pumping stations planned in this Project will be located near the existing reservoir No.7 and pumping station No.7; hence these facilities can be operated and maintained by the existing staffs. These facilities will be established within the territory of the existing facilities; therefore the stationed staffs will cover both old and new facilities.
- The stationed staffs mentioned above will monitor groundwater level of intake well and

observation well and the staff in charge of groundwater of Department of Water and Sanitation in MCDC will establish operation plan of wells based on observation result. For this purpose, soft component will be carried out.

- Distribution management by the distribution facilities which will be installed by the Project will be made by the existing staff of the distribution department. The capacity of water distribution engineer will be enhanced by the soft component through technical transfer.
- Chlorine disinfection facilities will be newly equipped at the 9 points (reservoirs, elevated tanks and water treatment plants) in the Project. The existing staff stationed in the facilities will be trained by OJT through technical transfer.
- Meter readers and collectors of revenue department in Pyi Gyi Tagon TS will be increased according to the increase of the metered customers by the project implementation.
- The increase of water supply flow rate will be realized by the Project, and the promotion and the increase of new contracted customers are an important element for the appropriate waterworks management of MCDC. Since many residents who are categorized as the low or middle income people live in the Pyi Gyi Tagon TS; hence public awareness activities for the residents needs to be enhanced by the soft component.

2－4－2. Operation and maintenance system

1) Water supply facilities for Pyi Gyi Tagon TS

The water facilities which will be newly established by the Project are intake wells, reservoirs, pumping station and chlorine disinfection facilities. MCDC already owns similar facilities to the facilities to be constructed by the Project. With regard to technical training on chlorine dosing facilities, Kitakyushu City will carry out technical guidance under the Grant Assistance for Grassroots Human Security Project. The other facilities except for chlorine dosing facilities will be located near the existing reservoir and pumping station No.7, hence these facilities can be operated and maintained by the existing staffs stationed in the sites.

The above stationed operators will also be responsible for the monitoring of intake wells. An operational plan for intake wells will be prepared by the staffs of the Department of Water and Sanitation responsible for groundwater development who belong to Electrical and Mechanical Section. Distribution management works will be done by the staffs of Distribution Section. The operational skills of the staffs will be expected to be trained by the OJT after the facilities installation. The obtained distribution data such as volume and pressure will be utilized by the activities of soft components as well as technology transfer of analytical methods.

Since the number of new contracted customer will be projected to be increased and the workload of meter reading, billing and collection will be mounted, 15 new staffs also need to be newly employed in accordance with it. As of 2020, the total new connections by the Project will be 8,952, which are planned to be the metered customers. The actual increase of new staffs should be according to the increase of the number of customer in a step-wise manner.

2) Monitoring system of groundwater level and O&M of intake wells

In the activities of soft components, it is planned to transfer the technologies on data collection and management such as “selection of monitoring wells for groundwater”, “Setting of monitoring specification” and “analysis of the monitoring results”. In addition, analytical methods for “linkage between data and intake volume” will be trained for the appropriate O&M practices of the intake wells.

Groundwater levels will be monitored by the stationed operators at BPS No.7 by checking new three wells and one monitoring well before its operation and its stoppage.

Groundwater levels at the operation and after the recovery should be monitored everyday. Also a report indicating the linkage between intake volume and groundwater levels for each well shall be made every day.

The staffs responsible for groundwater development in Electrical and Mechanical Section will prepare rainfall amount and river water level etc. in addition to the above information. Then the staffs will analyses groundwater level change and will prepare the operational plan for intake wells (intake volume).

3) Chlorine disinfection facilities

These facilities will be managed by the stationed operators of the existing water facilities. Pilot installation of chlorine disinfection facilities at WTP No.4 and the technical transfer for the O&M practices will be carried out by Kitakyushu City under the Grant Assistance for Grassroots Human Security Project. At the same time, OJT will be conducted, so that operation methods for the facilities are obtained by the staffs of distribution section. It will contribute to supply safe water. The implementation of OJT should be described in the tender documents.

Sodium hypochlorite produced by the Project facilities will be transported by containers. The staffs of distribution section will be responsible for this. Sodium hypochlorite produced by the BPS No.1 and BPS No.7 will be contained and loaded by overhead cranes into transportation trucks, and distributed to each dosing points. The transportation trucks are owned by WSD. After the transportation, the containers will be carried in the designated points.

4) Necessity of incremental staffs

The incremental number of metered customer will eventually be 8,952 connections. Therefore additional 15 meter readers/collectors will be newly required[11]. While, the actual increase of the number of staffs should be increased according to the scale-up of the number of customer in a step-wise manner.

[11] Current practice covers 1,165 connections by 1 permanent staff and 1 part-time staff, who conduct meter reading, bill distribution and tariff collection every 3 months. One person is responsible for 194 connections/ month (1,165 connections ÷ 3months ÷ 2 staffs=194 connections/month). Based upon this practice level, the estimation assumes that 1 person covers 200 connections here. The result shows that 16.9 persons are necessary for total connections ((1,165 connections+8,952 connections) ÷ 3months) ÷ 200=16.9 persons. New staffs are calculated by deducting current 2 staffs, thereby 15 persons will be newly required.

Table 2-35 Incremental staffing for O&M of the main Project facilities

Main Facilities	Incremental number of staffs	Monitoring system	Person in charge
Intake wells	0	Residential	Residential staff
Reservoirs	0	Residential	Residential staff
Distribution pumping station	0	Residential	Residential staff
Distribution and service pipeline	0	Patrol	Distribution section staff
Chlorine disinfection facilities	0	Residential	Residential staff
Water meter	15	Patrol	Reader and collector

(2) Operation and Maintenance Items

The operation and maintenance items for the management of water supply facilities by the Project are shown in the following table based on the aforementioned basic principles.

Table 2-36 Items of regular works and inspection for O&M of the main Project facilities

Facilities and Inspection Items	Daily	Weekly	Monthly	Yearly
Intake Wells				
Recording intake pump operation	○			
① Operation time/ hours				
② Abnormal vibration/ sound				
Checking and recording of flow meter	○			
Submission of record book	○			
Measuring and checking Insulation resistance value			○	
Checking and arranging spare parts and maintenance parts			○	
Taking apart pump and inspection (vibration, corrosion, blockage, etc.)				○
Reservoirs				
Checking and recording water level in the reservoir	○			
Checking and recording flow meter	○			
Submission of record book	○			
Checking leakage and crack			○	
Cleaning inside				○
Pumping stations				
Recording pump operation status				
① Electric current and voltage	○			
② Operating time/hours	○			
③ Distribution flow volume	○			
④ Vibration, abnormal sound, leakage	○			
⑤ Water pressure at ejection point	○			
Submission of record book	○			
Checking mechanical, electrical and instrumental equipment	○			
Oiling and greasing pump and motor			○	
Checking and arranging spare parts and maintenance parts (ground packing, mechanical seals, etc.)			○	
Measuring and checking insulation resistance value for motor				○
Taking apart pump and inspection (vibration, corrosion, blockage, etc.)				○

Facilities and Inspection Items	Daily	Weekly	Monthly	Yearly
Chlorine Disinfection Facilities				
Checking consumption and retained volume of calcium hypochlorite, dosing management	○			
Checking and replenishing chemical stocks	○			

2－5. Project Cost Estimation

2－5－1. Initial Cost Estimation

(1) Estimated cost borne by the Myanmar side

Table 2-37 Summary of cost summary borne by the Myanmar side

Total Estimated Cost: Approximately 163 thousand USD

Cost item	Estimated cost (thousand USD)
Commissions for Banking Arrangement (B/A) and Authorization to Pay(A/P)	24
Cost for power supply to disinfection facilities in BPS No. 7 and distribution reservoir and well intake facilities in water supply system for Pyi Gyi Tagon TS and disinfection facilities in BPS No.1	139
Daily allowance and transportation fee to participants of soft component	0

(2) Estimate conditions

- Estimation date: June 2014
- Exchange rate: 1US$= 103.16 yen, 1Kyat=0.112 yen (October, 2014)
- Construction and procurement period: Period of the detail design and work is as shown in the work process.
- Others: Calculation considering the accuracy required for Japanese Government grant aid cooperation scheme.

2－5－2. Operation and Maintenance Costs

(1) Estimated water tariff and income level

Monthly water consumption volume per household (hh) is estimated as 275 m^3/year based on the daily unit consumption volume as 130L/ person.

130 L/person/day x Average family number (5.8 persons) x 365day/ 1000 = 275 m^3/year/hh

Annual water tariff amount per household is estimated to be 15,125 Kyat by multiplying tariff rates for domestic as 55 Kyat/ m^3 by the above consumption volume. This water tariff amount is equivalent to 0.5% of the estimated average overall annual household income and 1.1% of the estimated average annual household income of lower income class including the bottom 20% in terms of the median values.

Overall respondents：

Monthly household income（median value）250,000 Kyat x 12 months = 3 million Kyat/ year/hh

15,125 Kyat/ year/hh ÷ 3,000,000 Kyat/ year/hh x 100 = 0.5%

Lower income class including the bottom 20%：

Monthly household income（median value）112,500 Kyat x 12 months = 1.35 million Kyat/ year/hh

15,125 Kyat/ year/hh ÷1,350,000 Kyat/ year/hh x 100 = 1.1%

The estimation results are far below the widely practiced benchmark as 4% of the annual household income for water supply; therefore, it can be concluded that the estimated water tariff is within the affordable level for local households. The reason for low percentage attributes to the relatively low tariff rate level.

(2) O&M costs

The operation and maintenance costs additionally required by implementing this Project are estimated as given below.

1) Water Supply Facilities for the Pyi Gyi Tagon TS

Items	Equipment and materials	Breakdown of O&M costs
Labor cost:		Incremental labor costs as approximately 340,000Kyat/ year/ person will be necessary due to increase of 15 meter readers. There is no other additional costs (Equipment from intake to distribution pump to be newly installed are the same existing BPS No. 7; therefore, the staff of BPS No. 7 can perform operation and maintenance).
Power cost:	(1) Submersible pump:	201,707Kyat/day 37kW x 20h x 3units x 8,250/9,080 = 2,017 kWh 2,017 kWh x 100 Kyat/kWh = 201,707 Kyat/day
	(2) Distribution pump:	218,062Kyat/day 75kW x 24h x 2units x 8,250/13,620 = 2,180 kWh 2,180 kWh x 100 Kyat/kWh = 218,000 Kyat/day
	(3) Disinfection equipment:	15,840Kyat/day Production：31kg・Cl_2/day x 4.0 kWh/kg・Cl_2 x 1.2（ancillary equipment）= 148.8 kWh/day Dosing：0.8 kWh x 12h = 9.6 kWh/day Total：(148.8+9.6) x 100 Kyat/kWh = 15,840 Kyat/day

Items	Equipment and materials	Breakdown of O&M costs
Chemical cost:	(4) Salt:	16,601Kyat/day 31kg・Cl_2/day x 3.5 kg/kg・Cl_2 = 108.5 kg/day 108.5 kg/day x 153 Kyat/kg =16,601 Kyat/day
Depreciation cost:		The operation and maintenance cost for water supply in the annual accounts of YCDC is the financial balance of the general account budget; therefore depreciation cost does not occur.
Total for the year:		340,000Kyat/ year x 15 persons（the maximum number） + 452,209kyat/ day (the total of (1)~(4)) x 365 day = 170,156,650Kyat/ year ≒170 million Kyat

2) Disinfection facilities for existing water supply facilities

Items	Equipment and materials	Breakdown of O&M costs
Labor cost:		No change (Operators in the existing water supply facilities will perform operation and maintenance work; therefore, there will be no change in the organization.)
Power cost:	(1) Chlorine manufacturing equipment	50,880Kyat/ day Production：106kg・Cl_2/day x 4.0 kWh/kg・Cl_2 x 1.2（ancillary equipment）= 508.8 kWh/day 508.8 kWh/day x 100 Kyat/day = 50,880 Kyat/day
	(2) Chlorine dosing equipment	4,620Kyat/ day Dosing：3.85 kWh x 12h = 46.2 kWh/day 46.2 kWh/day x 100 Kyat/kWh = 4,620 Kyat/day
Chemical cost:	(3) Salt	56,763Kyat/ day 106kg・Cl_2/day x 3.5 kg/kg・Cl_2 = 371 kg/day 371 kg/day x 153 Kyat/kg =56,760 Kyat/day
Depreciation cost:		The operation and maintenance cost for water supply in the annual accounts of YCDC is the financial balance of the general account budget; therefore depreciation cost does not occur.
Total for the year:		112,263 kyat (the total of (1)~(3)) x 365 days= 40,975,995Kyat/ year ≒41 million Kyats

The total annual operation and maintenance is estimated as 211 million Kyats.

(3) Incremental revenue from water tariff by the Project

Water tariff revenue for 8,249 m^3 per day is expected to be collected after the Project is completed in 2020. Leakage loss and commercial water loss are assumed as 10% of the total distribution volume respectively. The total revenue water volume is estimated to be 6,559 m^3.The amount expected to be collected as tariff is calculated considering the ratio of domestic use and non-domestic use (10:1) as follows:

Domestic water: 6,599 m^3 x10/11 x 365 days x 55 Kyat＝120,431,750 Kyat
Non-domestic water: 6,599 m^3 x 1/11 x 365 days x 77 Kyat＝16,860,445 Kyat
Total revenue from water supply: 137,292,195 Kyat

As a result, revenue from new system is estimated to be 137 million Kyats per annum from the new coverage areas of Pyi Gyi Tagon TS.

(4) Cost to be borne additionally by MCDC

The cost to be borne by MCDC additionally will be 74 million Kyat.

211 million Kyat - 137 million Kyat＝74 million Kyat

(5) Projection of financial balance

As mentioned above in (2), the incremental O&M costs for water supply service to be generated by the Project are accounted for 211 million Kyat, which will not be able to be covered by the incremental revenue as 137 million Kyat. It should be noticed, however, that this O&M costs include chemical costs of chlorine dosing for the existing water supply facilities.

The above incremental O&M costs for new water facilities for only Pyi Gyi Tagon TS is estimated as 170 million Kyat. The deficit between incremental tariff revenue and the O&M costs for new water facilities for only Pyi Gyi Tagon TS will be 33 million Kyat. As the result, the incremental tariff revenue will cover 81% of the incremental O&M costs.

Meanwhile, the most of revenue of MCDC is provided by the central government, and a self-accounting system for water and sanitation service is not applied. The average operating balance during the recent 3 years is calculated as plus 546 million Kyat if financial balance of water and sanitation service as a whole is made based on the information from MCDC[12]. The reason for positive financial balance may be explained by the fact that MCDC has not carried out the necessary investment for chemical dosing, water treatment, rehabilitation and renewal of water facilities for supplying hygienic and safe water, except for the minimum O&M costs such as power costs etc.

Looking at the current trend, the operating balance will be approximately 324 million Kyat surplus despite the deduction of the incremental costs as 74 million Kyat.

However, for the purpose of safe and hygienic water supply and an appropriate daily maintenance, it is necessary to make proactive investment. In addition, careful attention on the increasing trend of O&M costs and response to increase of maintenance costs by development of river water source and renewal of the aged pipes are necessary for future. Further consideration of tariff revision targeting cost recovery, measures for non-revenue water reduction and application of self-accounting system are significant challenges for MCDC.

The projection of financial balance for FY2019/2020 is shown in table 2-38.

[12] Water tariff revenue is presently collected by Revenue Department and is integrated into the revenue of that department. In this calculation, this tariff revenue is integrated into the total financial balance of water and sanitation services.

Table 2-38 Projection of financial balance for waterworks and sewerage works (2019/2020)

(1,000 Kyat)

Items	Actual	Estimated
	2013/2014	2019/2020
Operating Revenue	**1,304,422**	**1,441,714**
Water tariff (Kyat)	926,458	1,063,750
Water tariff (US$)	45	45
Connection fee	247,225	247,225
Rental fee for vacuum car	17,205	17,205
Others	113,489	113,489
Operating Expenses	**906,509**	**1,117,641**
Salary	280,621	285,721
Travel Costs	500	500
Material Costs	258,119	258,119
Operation and Maintenance Costs	352,446	558,478
Others	14,823	14,823
Balance	**397,913**	**324,073**

[Note]

- Price escalation and other future water supply projects except for the Project are not considered in the estimation.
- The revenue from connection fee for the new 8,309 connections is not taken into account in this estimation because it is assumed that the revenue is already collected before 2016.

Source: JICA Study Team