CHAPTER 6

WATER FACILITY DEVELOPMENT PLAN

CAPTER6 WATER FACILITY DEVELOPMENT PLAN

6-1 Basic Condition

6-1-1 Water Resource Options Consideration

The demanded water for the Thilawa SEZ is defined in accordance with the development plan of Thilawa SEZ.

Short-Term : by the business opening of Thilawa SEZ in 2015 6,000～10,000 m^3/day

Mid-Term : target by 2018 42,000 m^3/day

Long-Term : full development of the Thilawa SEZ 120,000 m^3/day

In the Short-Term Plan, the water resources and facilities to ensure the demanded water for the business opening of Thilawa SEZ in 2015 are considered. The period of the Short-Term is defined as the period up to develop completely the water facilities for the middle-term. In the Mid-Term Plan, the amount of 42,000m^3/day is planned to supply to the Thilawa SEZ as a target by 2018 under Yangon City Development Committee (YCDC).

Table 6-1-1 Water Resource Options

No	Water Resource	kind of the water resources	Design Intake Water (m^3/day)	certainty	notes
I	New Tube Well in the Thilawa SEZ area (new)	Ground water	1,000 (Consideration result)		emergency use only
II	New Tube Well on east plain of Thanlyin-Kyauktan Hill	Ground water	1,000 (Consideration result)		emergency use only
IIIa	from Zarmani-Inn Reservoir	Surface Water	6,000 (from Water right)	with Water Right	
IIIb	from Zarmani-Inn Reservoir	Surface Water	10,000 (Maximum demanded water for Short-Term)		
IV	from Ban Bwe Gon Reservoir	Surface Water	2,900 (Consideration result)	depend on the Water Right	
V	New Reservoir Construction in the Thilawa SEZ area (new)	Surface Water	4,000 (Additional demanded water for Short-Term)	depend on the land expropriation	720,000m^3/6months
VIa	from Khayan River	Surface Water	4,000 (Additional demanded water for Short-Term)	depend on the Water Right	10,000-6,000=4,000
VIb	from Khayan River	Surface Water	120,000 (Demanded water for Long-Term)	depend on the Water Right, requesting a development of Dawei Dam	Long-Term Plan
VII	from La Gun Byin Reservoir	Surface Water	42,000 (Demanded water for Mid-Term)	with Water Right	Mid-Term Plan

From the consideration results of the previous chapters, the water resource options having use availability for the Thilawa SEZ are shown in theTable 6-1-1. The considerations are carried out for the plans that have been extracted so far.

(1) Water Resources for Short-Term

In ”III from Zarmani-Inn Reservoir” case, the water right of 1,000acre-feet/year (about 3,000m^3/day) is agreed between Ministry of Agriculture and Thilawa SEZ Management Committee. Moreover, an additional water right of 3,000m^3/day is also agreed by each other in May 2014. Therefore the amount of total 6,000m^3/day from the Zarmani-Inn Reservoir is realistic plan.

And then, it is expected by the simulation of the dam operation that the amount of 5,030m^3/day can be supplied because of the rehabilitation of the spillway and dam crest. According to the current dam operation, an irrigation water was stopped from 2013, the water from the Zarmani-Inn Reservoir is only supplied for a domestic and a navy use. In this case, the demanded water of 10,000m^3/day from the Thirawa SEZ can be supplied physically. Therefore, a design intake flow is set to “IIIa: 6,000m^3/day” and “IIIb: 10,000m^3/day” for “III from Zarmani-Inn Reservoir” plan.

In the other plans without “VIb” and “VII”, these are evaluated for “III” as a complementary water resources, because the Thilawa SEZ needs an additional water to 10,000m^3/day for the business opening in 2015. In particularly “I” and “II” regarding groundwater, the use is concerned as follows:

1) As a result of the survey of existing wells, there are about 15,000 wells in the survey area, and it is found that the groundwater is a main water resource in the areas including a domestic use. Therefore, pumping up a huge amount of groundwater for Thilawa SEZ continuously is concerned about affecting the use of groundwater in future.

2) It is not expected to recharge the groundwater with rainwater because the geology of surface of the earth is a granular layer of low permeability.

3) Surrounding Thilawa SEZ is enclosed by a large river where salt water goes up from three sides. When the water level in the aquifer is lowered, there might be a saltwater intrusion. Actually, the water quality test result of the tube well in Thilawa SEZ carried out by the other team indicates numerical values (EC > 1,000) of the saltwater intrusion. If the saltwater intrusion occurs in the aquifer, it is quite difficult to recover.

For I and II, taking the groundwater continuously brings the groundwater pollution by the saline-water intrusion, and it is more likely to cause expansion of the surrounding existing well pollution. Therefore, taking the groundwater for the Thilawa SEZ is limited as the emergency use.

(2) Water Resources for Mid-Term and Long-Term

The demanded water for the Mid-Term and the Long-Term Plan is the amount of water that can not be supplied even if a plurality of the water resource option is adopted. Because the Mid-term Plan is being formulated under YCDC, the conveyance plan to the Thilawa SEZ is not mentioned in particular ("VII" in the Table 6-1-1). On the other hand, it is expected to be made a plenty of surplus water by constructing the Dawei Dam in the 30 miles greening project being developed by ID, in the Long-Term Plan. "VIb" in the Table 6-1-1, it is precondition to supply the surplus water apart from the issue of a water right negotiation.

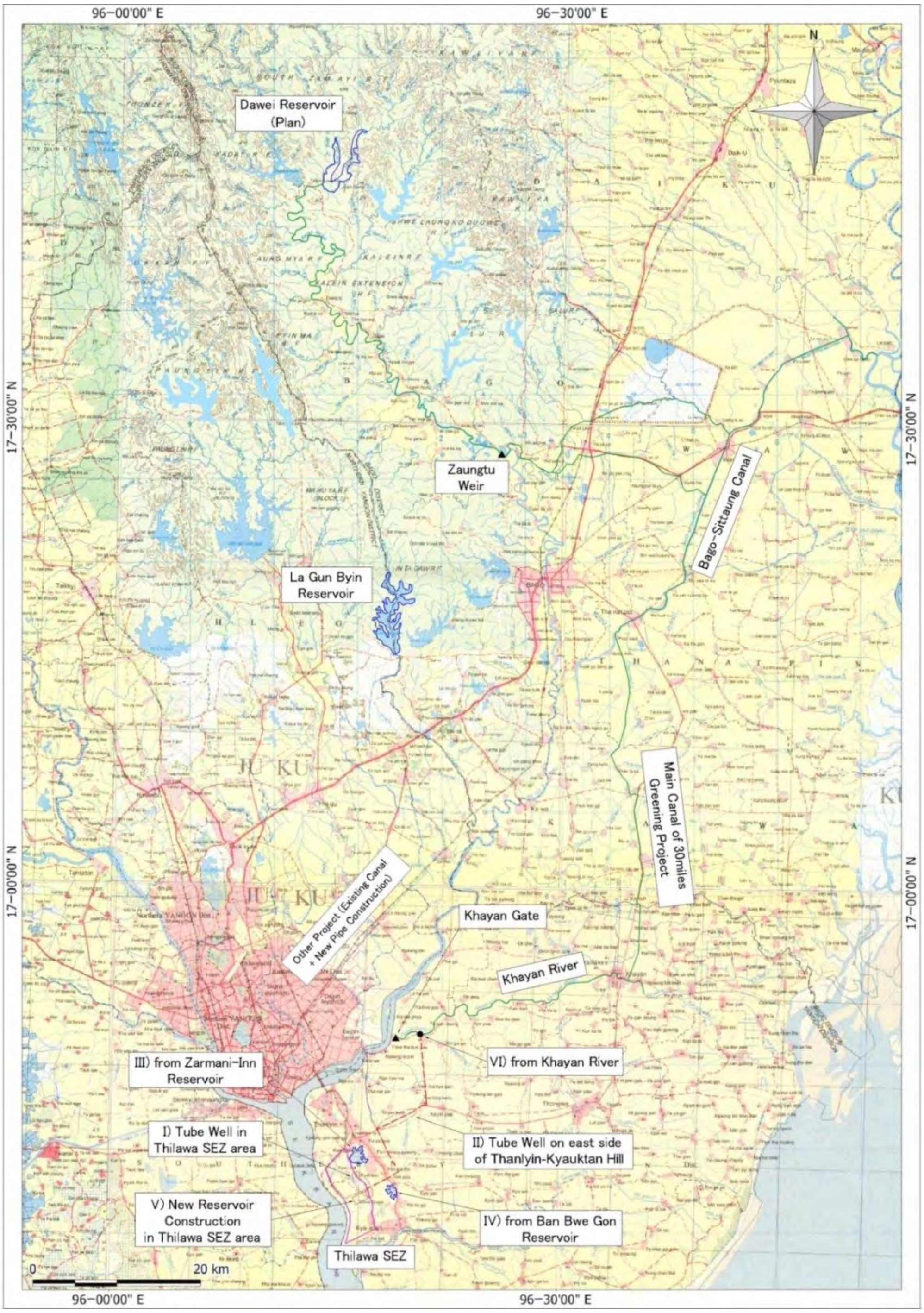


Figure 6-1-1 Location map of each water resources

6-1-2 Other Water Resources

There are a using possibility of the other water resources like as ”Reuse of Sewage Treatment Water ”, “Desalination of Seawater and Brackish Water” and “Underground Dam”, but their option is considered to be difficult by judging it overall.

(1) Reuse of Waste Water

Definition

The waste water caused by human life and activities is drained away along with processing in general. The treated water, having purified more than raw sewage, is called a reclaimed water. It is not like the quality of a drinking water. In Japan, the water quality of the reuse of waste water is the reclaimed water quality, and it is used for toilet, watering, cooling, extinguishing, cleaning and others. A combination of a biological treatment process and a membrane process is major method about the treatment method on the reusing system of the waste water in Japan, and water quality standards have been established by the purpose of the usage.

Feature of the Method

An activated sludge process is a general treatment method for the sewage water. This is a method to sediment and separate coagulated bacteria of multiplying itself, with controlling the pollutant concentration and aeration, and dissolving the pollutant to aerobic microorganisms by aerating the sewage water. In case of reusing the treated water as the reclaimed water, an advanced water treatment facilities are required. Moreover, for reusing it as a water supply, it is necessary to build in the advanced water treatment process like as an activated carbon adsorption and an ozonation to existing treatment plant.

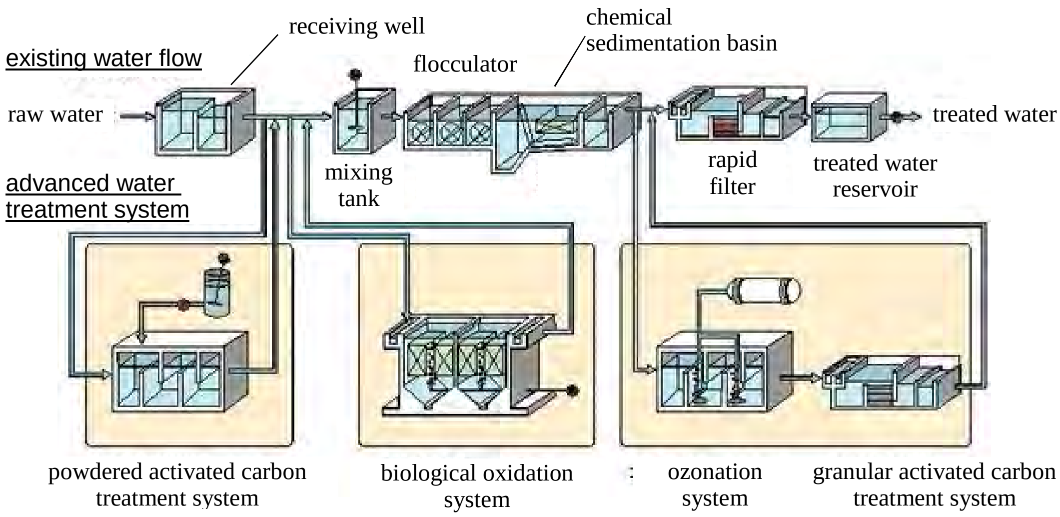


Figure 6-1-2 Flow of Advanced Water Treatment System

And then, to supply the sewage water stably, it is assumed to be a region which has been developed in the drainage system to ensure the stable amount of waste water.

Adequacy

1) Problem of Initial and Running Cost

When a purpose of the reuse water is for industrial, the advanced treatment facility is required in addition to the normal sewage treatment. On the other hand, when the water quality is assured for drinking, the advanced water purification process is required moreover.

There are purification plants that can be purified from the sewage water to the drinking water in the United States or Singapore. But there are few examples, and the initial cost is expensive at this time. On the other hand, the power supply is required continuously for the advanced treatment, but there is not so enough power in Myanmar, in current condition. Moreover, it is necessary to supply consumable materials for the additional process in the advanced treatment. Therefore, it is expected that the running cost is clearly high and the continuous operation is difficult.

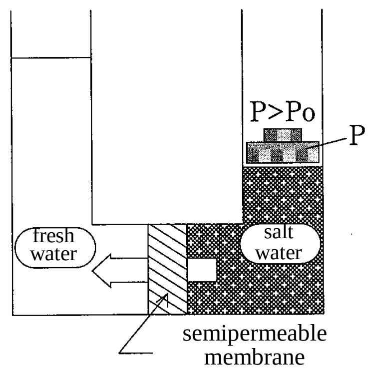
2) Problem of the amount of sewage water

When the waste water is reused, it is necessary to ensure the stable amount of the water. But the drainage system of the domestic waste water is not developed around the Thilawa SEZ. Even if the system is developed, without the possibility that a water supply or domestic water required for life is supplied to enough, there is no assurance to ensure the stable amount of waste water. And also, when a brackish water of Bago River is mixed with the waste water, the water quality will be a problem. In this case, the advanced water purification process is required, and the initial and running cost is pressured.

(2) Desalination of Seawater and Brackish Water

Definition

The Thilawa SEZ is located along the left bank of Yangon River. Abundant amount of water in the Yangon River can enough supply the demanded water for the Thilawa SEZ, but the river water is brackish because near the river mouth. A desalination facility can be a water shortage measure in good locational condition, but the water production cost is generally higher than the cost by existing facility.



source: Water purification technology guidelines

Figure 6-1-3 A Reverse Osmosis

Feature of the Method

The desalination method which is practically used at present, there is a evaporation and a reverse osmosis method, mainly. The evaporation method was put to practical use earliest technically, but there were much energy consumptions. The reverse osmosis membrane method becomes the mainstream because the cost is reducing by developing a membrane in recent years. The reverse osmosis membrane method is a method to get freshwater using semipermeable membrane which the water passes but the salt is hard to pass.

The reverse osmosis method was adopted in Uminonakamichi Nata Sea water Desalination Center (Fukuoka District Waterworks Agency) on March 2005. It is able to supply the amount of 50,000m^3/day of freshwater. In the case of the desalination of the reverse osmosis method, a recovery of the freshwater for the raw water is 40 - 60%.

In general, a maintenance cost of the desalination plant is high, and the cost is nearly the double in comparison with a water purification plant. It is said that a quarter of the cost is the electricity bill.

Adequacy

A stable power and water supply is required in an industrial park. In Myanmar, the electrical power condition is not good, and can’t be estimated to supply it stably. A power source of petroleum is expected to be operated the desalination plant. In any, there is much energy consumptions, a maintenance cost of the plant including exchanging the membranes is high.

In the example of Okinawa, a construction and maintenance cost of the desalination plant is 280 Yen/m^3 of the desalinated water against 100 Yen/m^3 of the purified water (source: Ministry of Land, Infrastructure and Transport, Kanto Regional Development Bureau). In this situation, there is no significance to be introduced over the cost, because other water resources have a use availability.

(3) Underground Dam

Definition

By providing a cut-off wall into the geological formation of large porosity and pooling by damming the groundwater flow, the facility which made available a stable groundwater is underground dam.

Feature of the Method

Because a dam body of the underground dam is constructed into the geological formation, it is possible to store the water without disturbing the current state of the land use. Because of storing the water under the ground, the water temperature and quality are kept stable. Moreover, the flow of underground water is comparatively late, and it is possible to take the water stably for a long time, because the groundwater which penetrated under the ground is gradually recharged in the retention area, in a great quantity of rain even at the time of a drought.

On the other hand, water storage efficiency of the groundwater is low and accurate grasp is difficult, because it is depend on the effective porosity of the geological formation. In the choice of the construction site for the underground dam, it depends on the estimate of the underground geological feature structure because it is not possible to confirm visually in spite of the various natural conditions being required.

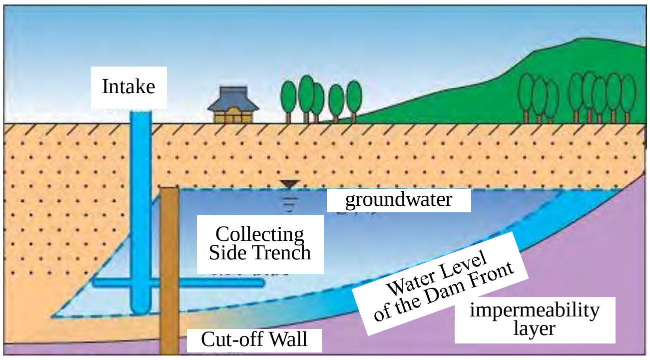


Figure 6-1-4　Underground Dam

Adequacy

The geological formation near Thilawa SEZ is the sedimentary layer of Tertiary period, and there are no impermeability bedrock and permeability layer for recharging the groundwater. Therefore, it is not feasible around this target area.

6-1-3 Condition for Consideration

For the necessary facilities to convey the water from each water resources to the Thilawa SEZ, the conditions for the consideration are shown as follows:

(1) Target facility

1) Intake Facility

In the case of Surface Water, it is important to take the water stably at the time of drought and flood. A pumping station (on the ground construction pump) is selected for taking the water from existing dams in the target area. When the river water is taken, it is from an intake by the pump.

Figure 6-1-5　Intake Facility
(Pumping Station)

In the case of Groundwater, an excessive pumping for groundwater brings a reduction of the amount of taking water by the result of drawdown. Moreover, sometimes it brings a land subsidence, it is necessary to pay attention to the amount of taking water. A deep well of 100-150 meter in depth is suitable for an intake facility for groundwater in the target area.

2) Water Storage Facility

For stable water supply, it is important to ensure the water resource that can take the design intake flow stably through the year. In this target area, the water storage facility is not necessary because there is a large amount of water in the surface water resource. When the water is conveyed to the high position by pumps, it is pumped up progressively by constructing a temporary water storage tank in a relay point.

3) Water Conveyance Facility

A water conveyance facility is the facility carrying the raw water taken at the water resource to the purification plant. It consists of pipeline, pumping facilities etc. In the event of an accident, it might have a negative impact on the wide area by stopped or reduced the water supply. Therefore, it is required to carry the demanded water amount certainly, and to have a high reliability.

A gravity flow is economic generally. However, when the elevation of the water resource is lower than surrounding Thilawa SEZ area and crossing mountain water supplies, pumping system can be selected. In this case, pipe material can be selected “Polyvinyl Chloride Pipe” and “Ductile Cast Iron Pipe” as a pressure pipe proven in Myanmar.

4) Purification Facility

A purification plant is the central water facility, and the functions affect the whole water supply system directly. The function of the purification facility is requested to ensure stably both a required water quality and quantity.

The purification plant for industrial is the facility to carry out the water purification such as sedimentation or coagulation for the raw water. In Japan, the general-standard water quality for industrial is established. When the water quality more than the standard is required, the customers carry out the purification in themselves according to their purpose. In the water purification of industrial water supply, a sedimentation of earth and sand is mainly processing, and a chlorination is not done in most cases. On the other hand, the purification may not be done for the purpose of cooling use.

In this target area, the purification plant is requested for the purpose of drinking use. However, it is not clear that the number and type of companies which goes into Thilawa SEZ at present. And then, the developer of the Thilawa SEZ is expected to plan the purification plant by themselves. Therefore, the purification facility and the water facilities after the purification (water transmission, distribution and so on) are not considered.

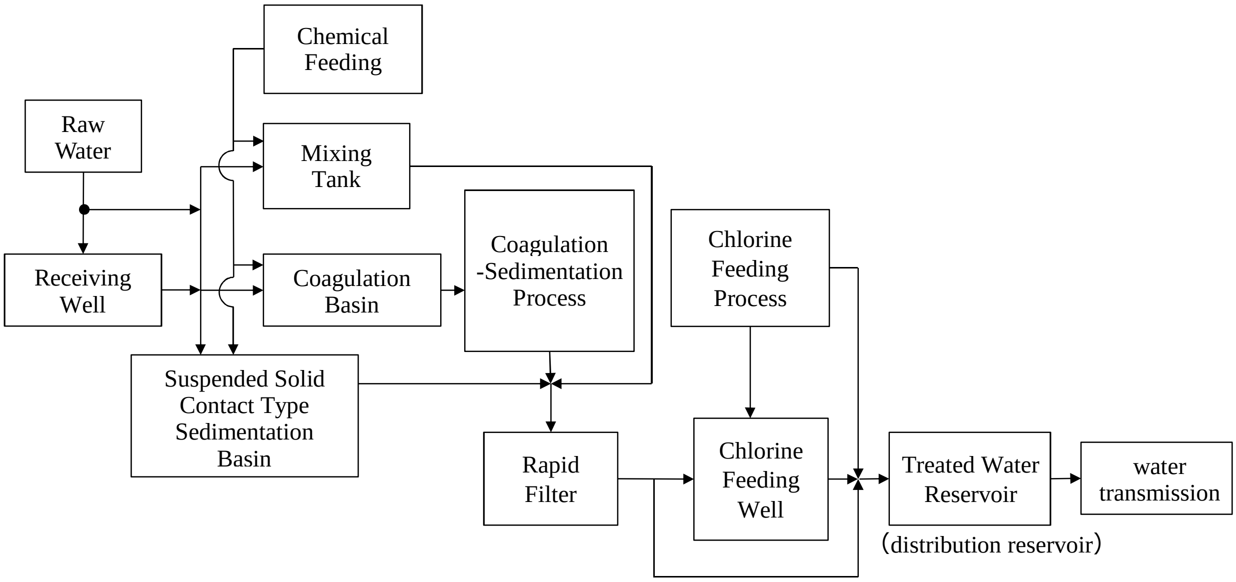
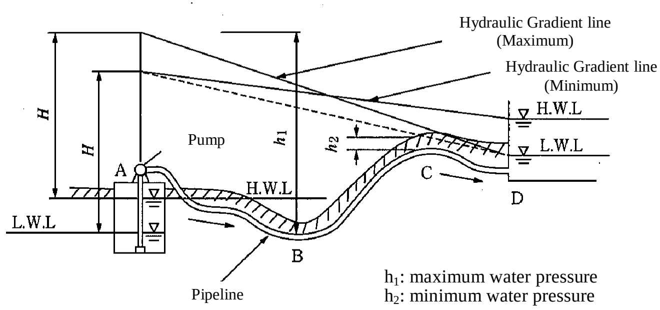


Figure 6-1-6 Flowchart of a Purification Plant (ex. Rapid Sand Filtration Method)

(2) Consideration of Water Conveyance Pumps

In the consideration of the pump facilities, pump specifications, such as the number of pump, discharge quantity, pumping head and so on, is decided with including pipeline system plan. The pump is selected with reference to the pump performance curve of the supplier.



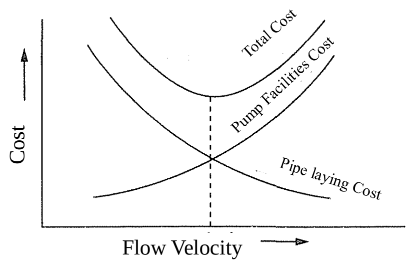
source: water facilities design guidelines

Figure 6-1-7 Hydraulic Gradient line

In the pumping system, the total head is decided by head losses and a difference in water level between the low water level of pumping well and the water level of the transfer point to the Thilawa SEZ. The water level of the transfer point equal its ground elevation.

At this time, it is concerned about the friction loss of pipeline is increased when the pump-sending distance becomes very long according to the position of the water resource. In this case, to pump again after release pressure once by constructing a booster pumping station, economical combination of pumps and pipelines should be selected.

In the pumping system, a pipe laying costs be cheaper when the pipe diameter is reduced. However, the pump head increases, in that case, because the friction loss increases. Therefore, it is uneconomical not only the pump facilities cost increases, but also the power cost increases in the future. On the contrary, a pipe laying costs be higher when the pipe diameter is increased, but the cost of related pump facility is reduced. The economical combinations are referred in Figure 6-1-8[1]. In here, a consideration of water hammer is omitted, and it will be considered in the implementation stage separately.



Diameter (mm)	Average Flow Velocity (m/s)
75 ～ 150	0.7 ～ 1.0
200 ～ 400	0.9 ～ 1.6
450 ～ 800	1.2 ～ 1.8
900 ～ 1,500	1.3 ～ 2.0
1,600 ～ 3,000	1.4 ～ 2.5

source: Land improvement business plan design standards "pipeline"

Figure 6-1-8　Concept of the Economy, Average Flow Velocity of Pumping System

(3) Consideration of Pipeline System

The water conveyance pipe is requested to convey the design intake flow surely. For this purpose, it is safe to calculate the pipe diameter which the hydraulic gradient is minimized, and it is necessary to consider the above-mentioned economical matter.

To calculate the friction losses for pipeline, the pipe diameter and head losses is considered by using a Hazen-Williams' equation.

$$V = 0.849 \cdot C \cdot R^{0.63} \cdot I^{0.54}$$

where *V*: average flow velocity (m/s), *C*: coefficient of velocity,
R: hydraulic mean depth (m), *I*: hydoraulic gradient

Each the following formula is derived for the circular pipe in the above.

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54}$$

[1] The flow velocity of the pump system is better to decide by the economic comparison so as to minimize the sum of the pump facilities costs and pipe laying costs for the flow rate. The Figure 6-1-8 is shown in reference to the basis of the past achievements.

$$Q = 0.279 \cdot C \cdot D^{2.63} \cdot I^{0.54}$$
$$D = 1.626 \cdot C^{-0.38} \cdot Q^{0.38} \cdot I^{-0.21}$$
$$I = hf / L = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85}$$

where, D: pipe diameter (m), hf: friction head loss (m), Q: flow rate (m^3/s), L: pipe length (m)

The coefficient of velocity C is shown in Table 6-1-2.

In the consideration of pipeline, following points are noted.

- The minimum flow velocity in pipe is 0.3 m/s and more in order to prevent the sedimentation of the suspended solids in water.
- When the pipe length is long, the pipe diameter is decided by considering the economical flow velocity (refer to Figure 6-1-8).
- The head loss is allowed for 1.3 times of the friction head loss by considering the pipe losses (inflow, out flow, refraction etc.) excluding the friction head loss.
- The transfer point to the Thilawa SEZ is set to the intersection of the main road with the D-1 tube well in the roadside and the border line of the Thilawa SEZ, because the location of the purification plant is not clear.

Table 6-1-2 Coefficient of Velocity (C)

pipe (inner face)	coefficient of velocity (C)		
	max	min	average
cast-iron pipe (without paint)	150	80	100
steel pipe (without paint)	150	90	100
coal tar coated pipe (cast-iron pipe)	145	80	100
tar epoxycoated pipe (steel)			
φ800mm and more	-	-	130
φ700-600mm	-	-	120
φ500-350mm	-	-	110
φ300mm or less	-	-	100
mortar lining pipe (steel, cast-iron pipe)	150	120	130
centrifugal reinforcement concrete pipe	140	120	130
prestressed concrete pipe	140	120	130
polyvinyl chloride pipe	160	140	150
polyethylene pipe	170	130	150
fiberglass reinforced plastic mortar pipe	160	-	150

6-2 Water Facility Development Plan for the Short-Term

In this chapter, the outline of water facilities to supply the demanded water to the Thilawa SEZ for the Short-term is considered. And the comparison of the water resource options is carried out by estimating the cost of the water resource development.

In Zarmani-Inn Reservoir, the water right of 6,000m^3/day is agreed between Ministry of Agriculture and Thilawa SEZ Management Committee. Taking water from existing surface water resources is most realistic plan for the amount of additional water which is necessary up to 4,000m^3/day after the business opening of Thilawa SEZ. Moreover, using the groundwater resources as emergency is one of the best way to develop the water facilities in the short-term.

6-2-1 Facility Design

(1) New Tube Well in the Thilawa SEZ area

1) Outline of the Plan

It is planned a new tube wells in the Thilawa SEZ as the additional water resource. The location of the tube wells is the east of inside the Thilawa SEZ, where can be recharged from Thanlyin-Kyauktan Hill. The aquifer targeted by taking the groundwater is the second confined aquifer (Depth about 100m).

The water right is no problem because it is the use of groundwater. However, there are many existing production wells in the Thanlyin-Kyauktan township. Therefore, the use of groundwater must be as lternative water resources in emergency, because the impact on the surrounding environment is a concern when pumping large amounts of the groundwater at a time.

2) Consideration of the Facilities

a) Amount of Intake Water

Q = 1,000 m^3/day = 0.70 m^3/min = 0.012 m^3/sec (= 0.23m^3/min×3)

b) Target Facilities

Tube well, Water conveyance pipe

c) Pipe Material

PVC150 mm

d) Pipeline Extension

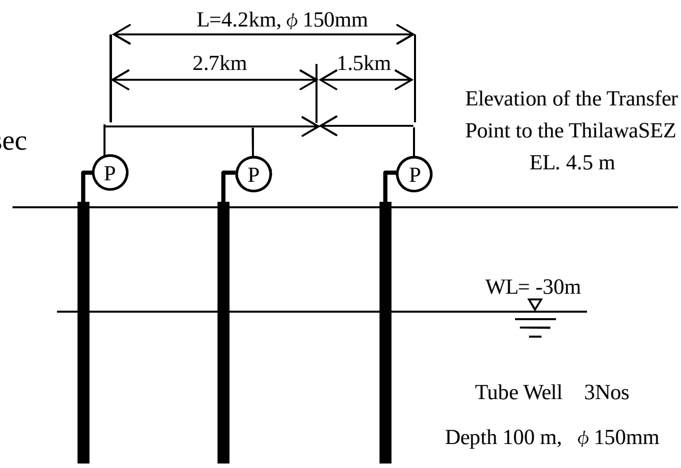


Figure 6-2-1 Layout Drawing of Tube Wells in Thilawa SEZ

L = 4.2 km = 4,200 m

(Distance from the farther pump to the Thilawa SEZ ; 2.7km = 2,700m)

e) Head Loss

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 150^{-1.85} \times 0.15^{-4.87} \times 0.012^{1.85} \times 2,700$$
$$= 7.8m$$

Head Loss H = hf ×1.3 = 7.8m×1.3 = 10.1 m

f) Flow Velocity in Pipe

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54}$$
$$= 0.355 \times 150 \times 0.15^{0.63} \times (7.8 / 2,700)^{0.54}$$
$$= 0.7m / \sec$$

Figure 6-2-2 Outline Planning (I New Tube Well in the Thilawa SEZ area)

The elevation of the transfer point to the Thilawa SEZ is 4.5m. The number of tube wells in the Thilawa SEZ is three, and the depth of the tube well is around 100m up to the second confined aquifer. And then, the groundwater level is under the ground of 30m.

The collected water from the tube wells is pumped to the Thilawa SEZ by a collecting pipe. The total head of the well pump is 44.6m by calculated as 30 m + 4.5 m + 10.1 m = 44.6 m including the head loss of the collecting pipe.

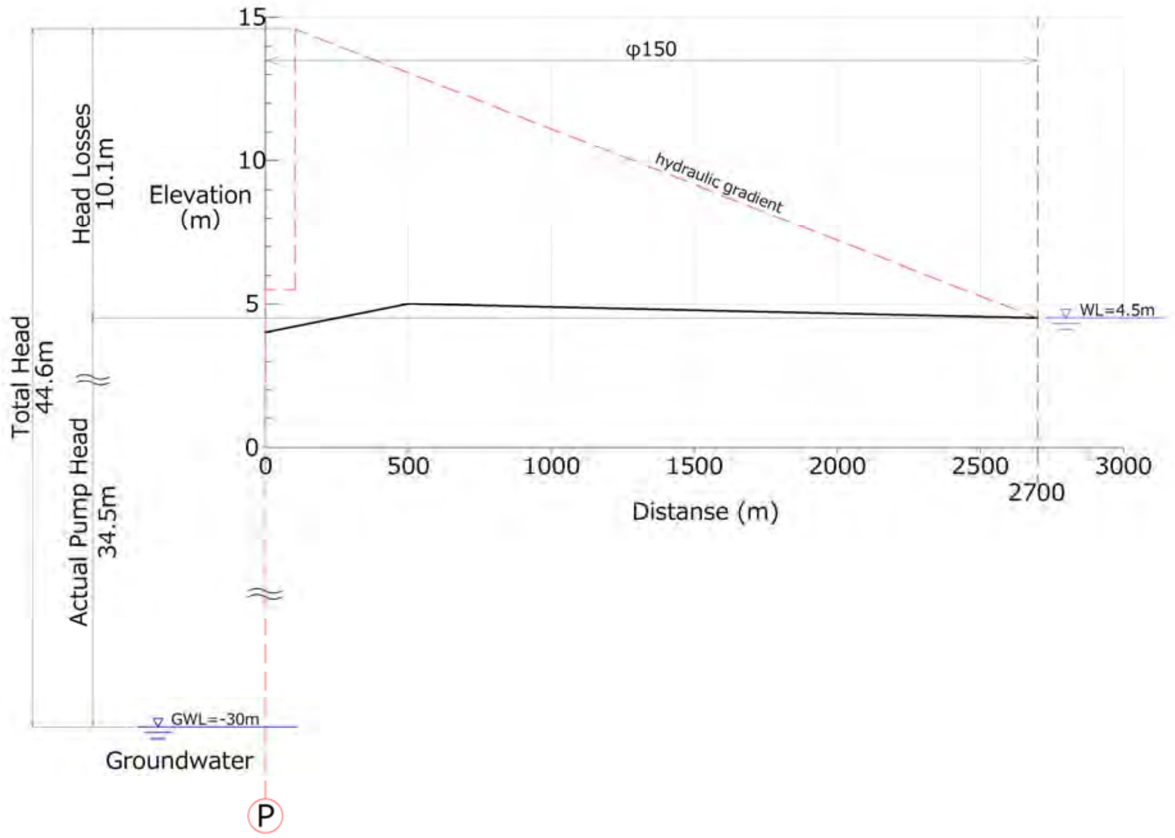


Figure 6-2-3　Hydraulic Gradient Line (I New Tube Well in Thilawa SEZ area)

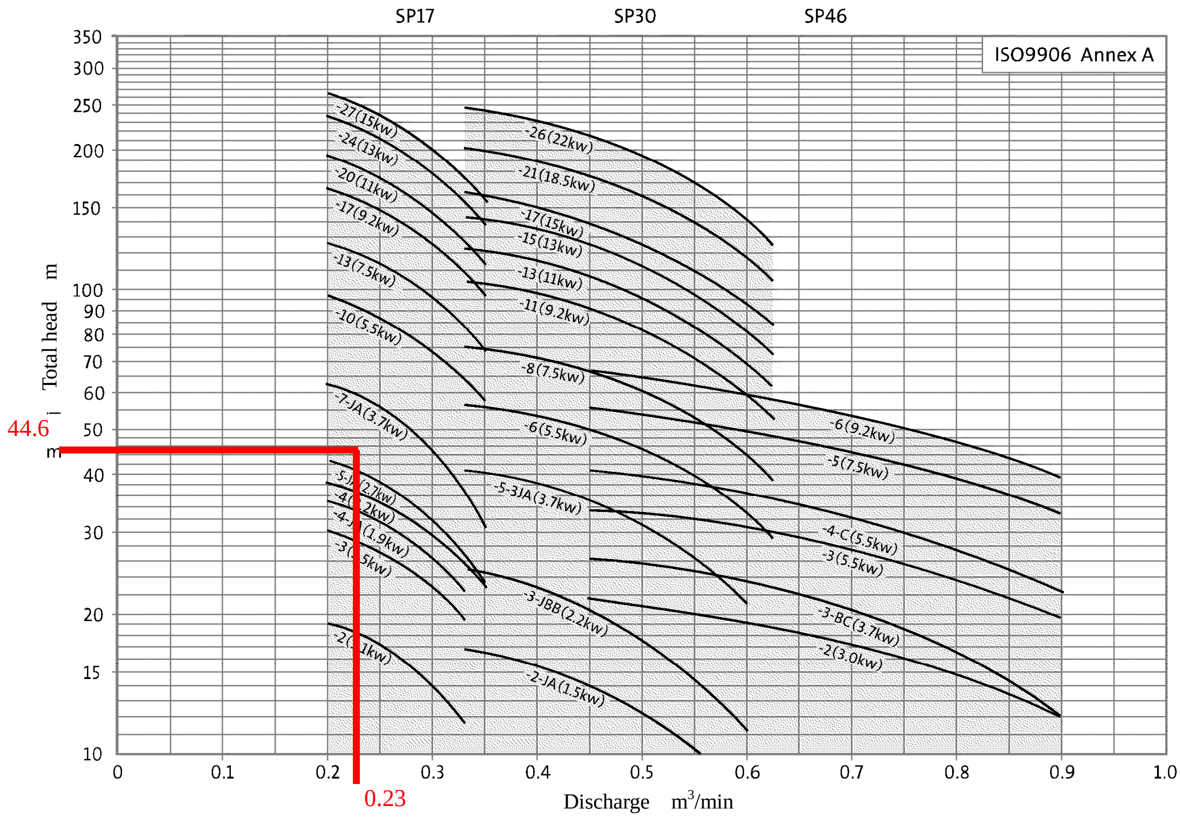


Figure 6-2-4 Performance Curve (I New Tube Well in the Thilawa SEZ area)

Tube Well (mm)	Dia. (mm)	Model	Motor (kW)	Connection	Item				A	B	C	D	E	Weight
					Discharge (m³/min)	Total Head (m)	Discharge (m³/min)	Total Head (m)	(mm)	(mm)	(mm)	(mm)	(mm)	(kg)
150	50 (65) (80)	SP17-2	1.1	Flange	0.2	19	0.333	11.7	748	305	443	95	131	14.9
		SP17-3	1.5		//	30	//	19.4	849	345	504	//	//	17.5
		SP17-4-JA	1.9		//	35.4	//	22.3	1020	456	564	//	//	24
		SP17-4	2.2		//	39.4	0.35	22.6	//	//	564	//	//	//
		SP17-5-JA	2.7		//	43.7	//	23.4	1121	496	625	//	//	26
		SP17-7-JA	3.7		//	63	//	31	1322	576	746	//	//	33
		SP17-10	5.5		//	98.1	//	57.1	1508	565	943	143	142	55
		SP17-13	7.5		//	128	//	74.8	1735	610	1125	//	//	63
		SP17-17	9.2		//	166	//	97	2002	635	1367	//	//	71
		SP17-20	11		//	196	//	114	2286	738	1548	//	//	82
		SP17-24	13		//	236	//	138	2573	783	1790	//	//	91
	50 (65)	SP17-27	15		//	266	//	156	2810	838	1972	//	//	101
	65 (50) (80)	SP30-2-JA	1.5		0.333	16.8	0.6	7.7	848	345	503	95	131	17.5
		SP30-3-JBB	2.2		//	24.7	//	11.2	1055	456	599	//	//	24
		SP30-5-3JA	3.7		//	41	//	21.2	1367	576	791	//	//	33
		SP30-6	5.5		//	56.7	0.625	28.9	1468	565	903	143	142	53
		SP30-8	7.5		//	75.7	//	38.9	1705	610	1095	//	//	61
		SP30-11	9.2		//	103	//	52.5	2018	635	1383	//	//	69
		SP30-13	11		//	122	//	62.2	2313	738	1575	//	//	79
		SP30-15	13		//	142	//	73.2	2550	783	1767	//	//	88
		SP30-17	15		//	161	//	83.8	2797	838	1959	//	//	97
		SP30-21	18.5		//	200	//	105	3269	903	2366	//	//	111
		SP30-26	22		//	245	//	127	3869	1023	2846	//	//	132
	80	SP46-2	3	Rp3	0.45	21.8	0.9	12	976	496	480	95	141	25
		SP46-3-BC	3.7		//	26.3	//	12	1169	576	593	//	//	29
		SP46-3	5.5		//	33.8	//	19.8	1174	565	609	143	145	51.5
		SP46-4C	//		//	40.6	//	22.1	1287	565	722	//	//	55.5
		SP46-5	7.5		//	55.7	//	32.6	1445	610	835	//	//	60
		SP46-6	9.2		//	67.1	//	39.7	1583	635	948	//	//	65.5

Figure 6-2-5 Selection of the Pump (I New Tube Well in the Thilawa SEZ area)

g) Result of the Consideration

Design Intake Flow	1,000m^3/day (333m^3/day × 3)
Water Resource	Deep Well (Groundwater)
Intake Facilities	Diameter of the Tube Well: 150mm, Pump: 50mm × 3.7kw × 3 Discharge: 1,000m^3/day = 0.70m^3/min (0.23m^3/min × 3) Total Head: 44.6m
Water Conveyance Facilities	PVC 150mm; L = 4.2km

(2) II) New Tube Well on east plain of Thanlyin-Kyauktan Hill

1) Outline of the Plan

It is planned a new tube wells on east plain of Thanlyin-Kyauktan Hill as the additional water resource. The draft plan of the location of tube wells is shown in the Figure 6-2-6.

The water right is no problem because it is the use of groundwater. However, there are many existing production wells in the Thanlyin-Kyauktan township. Therefore, the use of groundwater must be as optional water resources in emergency, because the impact on the surrounding environment is a concern when pumping large amounts of the groundwater at a time.

The alternative plans are proposed as follows.

- Case 1 Along the East-West road.
- Case 2 Along the North-South road
- Case 3 Along the North-East road

The pipeline route should be selected with an emphasis on impact on the surrounding environment and water quality. The collected water from the tube wells is pumped to the Thilawa SEZ by a collecting pipe. Because the pipeline extension from the tube well to the Thilawa SEZ is so long, a consideration of water hammer is required separately.

According to the result of the test well drilling and pumping test, the deeper aquifer can be expected to take the good quality groundwater with enough quantity more than the secondary aquifer (depth of 100m to 150m). The Mauung River located south of the Thilawa SEZ, is the tidal river, and the Padagyi River, which is a tributary of the Mauung River, having none of the salt prevention gates, is affected by the tide. From the aspect of the salt intrusion, among the above-mentioned three cases, the nearest location to the Padagyi River has the possibility of the salt intrusion.

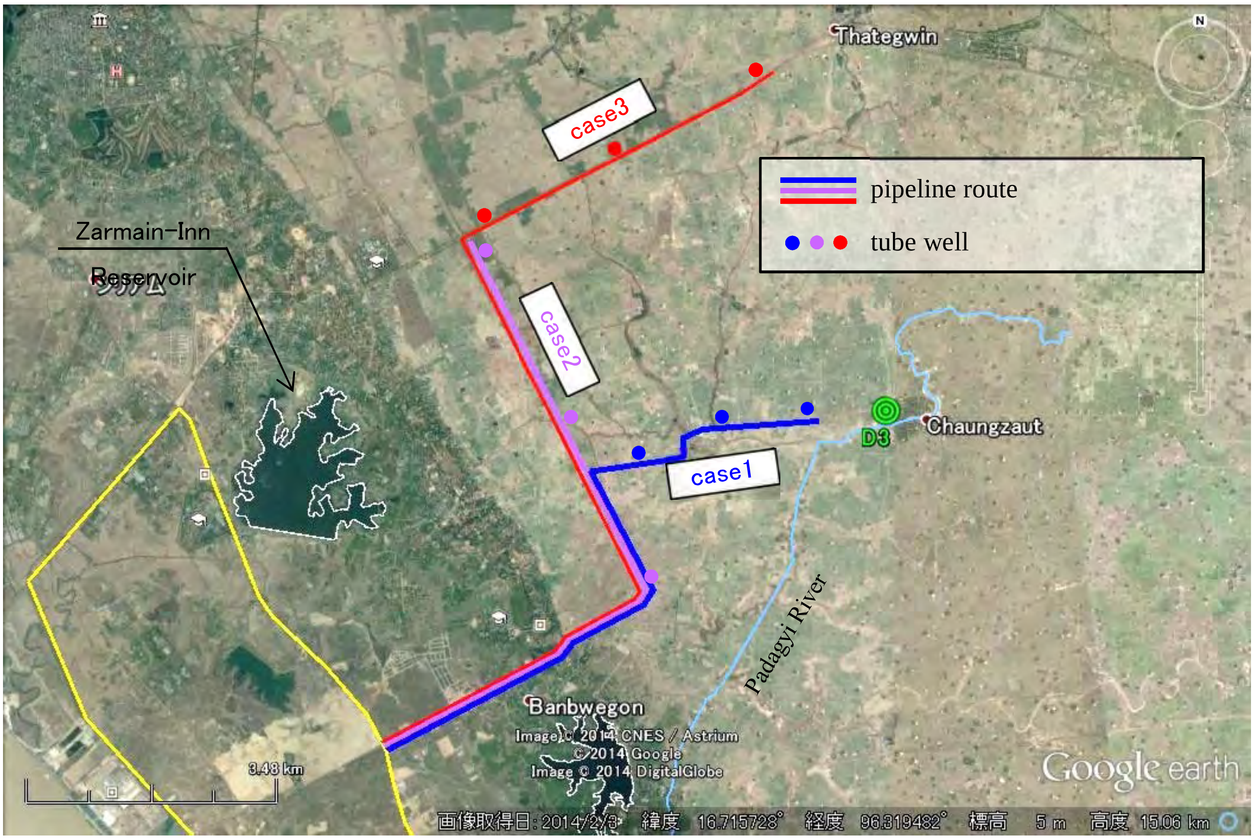


Figure 6-2-6　Alternative Pipeline Routes on East Plain of Thanlyin-Kyauktan Hill

After careful consideration, Case 3 is selected as the most suitable site for the production well sites.

The site of Case 1 is located at the nearest site from the Padagyi River and has the disadvantage compared with the other two cases due to the high possibility of the salt intrusion. The production wells are constructed along the East-West road between the central zone of the Thanlyin Township and villages located in the plane areas where the road is not paved. The road condition during the rainy season makes it difficult to keep good traffic conditions through the season. From the viewpoints of the operation and maintenance (O/M) for the production wells located around the sites, the improvement of the existing road shall be implemented in parallel with the construction of the wells. Furthermore, the negative impact, like the reduction of the water level, will cause anxiety by the continuous pumping up of the groundwater against the existing wells in the two villages located along the road.

The site of Case 2 is located along the North-South road. Its plan has much possibility to receive the recharge water from the ridge, because of the location of the road which is aligned with the Thanlyin-Kyauktan ridge. On the other side, there are many existing shallow wells along the ridge where the negative impact, like the reduction of the water level, will cause anxiety by the continuous pumping up of the groundwater against the existing wells.

The site of Case 3 is located far from the Padagyi River compared with other two plans, and the possibility of the salt intrusion is lower than in the other plans. Moreover, there are few existing wells, so the possibility of the reduction of the water level of the existing wells are also few.

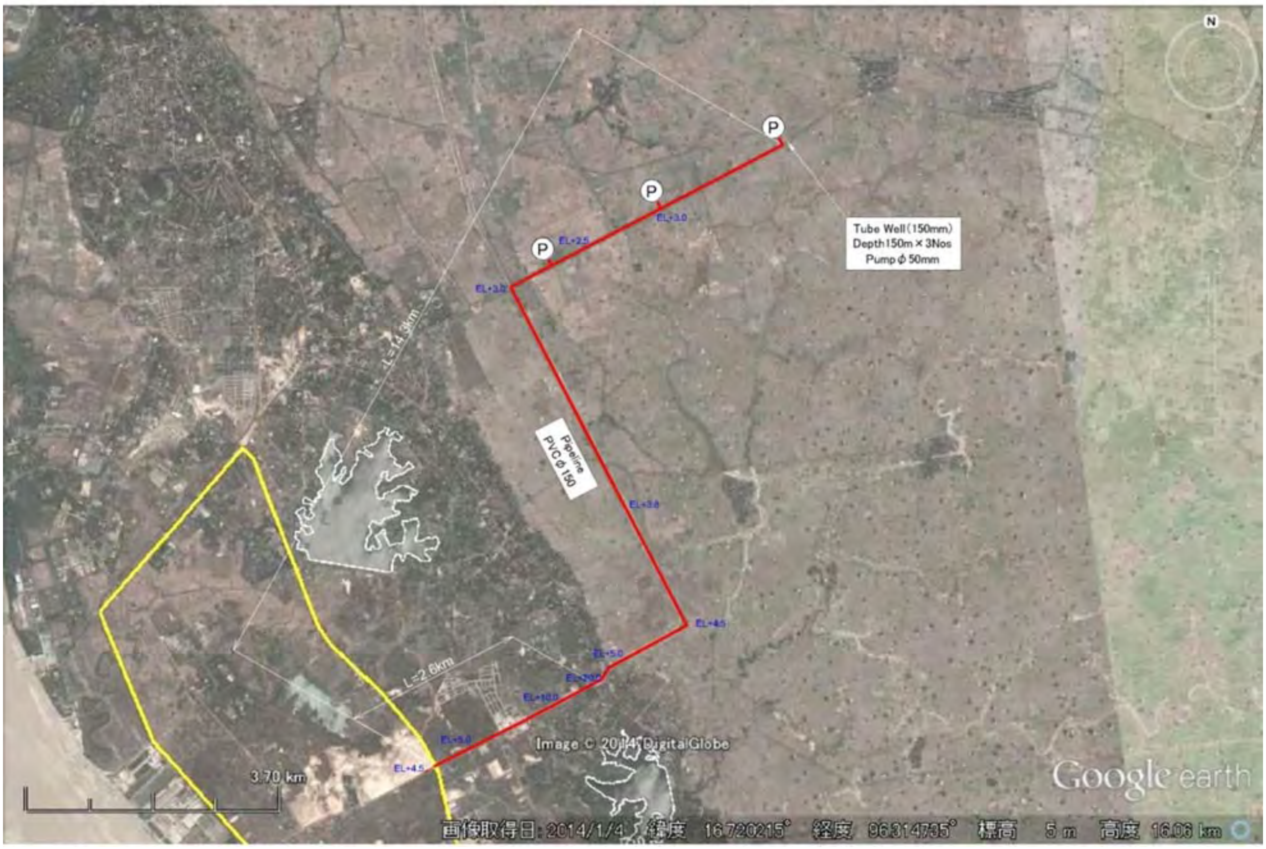


Figure 6-2-7 Outline Planning (II New Tube Well on east plain of Thanlyin-Kyauktan Hill)

2) Consideration of the Facilities

a) Amount of Intake Water

$Q = 1{,}000\ m^3/day = 0.70\ m^3/min = 0.012\ m^3/sec$
$(= 0.23 m^3/min \times 3)$

b) Target Facilities

Tube well, Water conveyance pipe

c) Pipe Material

PVC150 mm

d) Pipeline Extension

L = 14.3km = 14,300 m

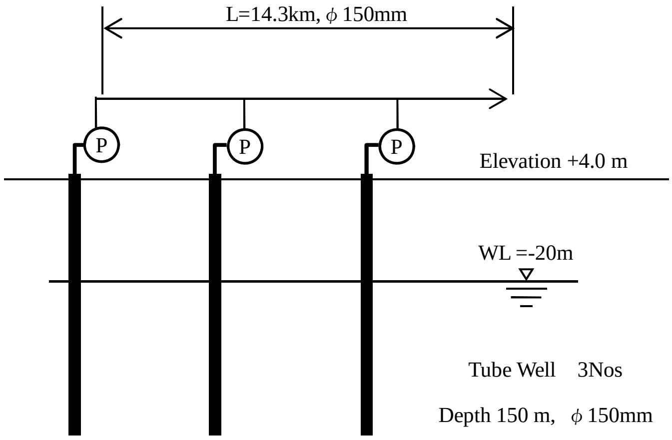


Figure 6-2-8 Layout Drawing of the Tube Wells on East Plain

e) Head loss

(Tube well - Highest point of the pipeline)

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 150^{-1.85} \times 0.15^{-4.87} \times 0.012^{1.85} \times 11{,}700$$
$$= 33.8m$$

Head Loss H = hf ×1.3 = 33.8m×1.3 = 43.9 m

(Highest point of the pipeline - the Transfer point of the Thilawa SEZ)

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 150^{-1.85} \times 0.15^{-4.87} \times 0.012^{1.85} \times 2{,}600$$
$$= 7.5m$$

Head Loss H = hf ×1.3 = 7.5m×1.3 = 9.8 m

f) Flow Velocity in Pipe

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54}$$
$$= 0.355 \times 150 \times 0.15^{0.63} \times (33.8 / 11{,}700)^{0.54}$$
$$= 0.7m / \sec$$

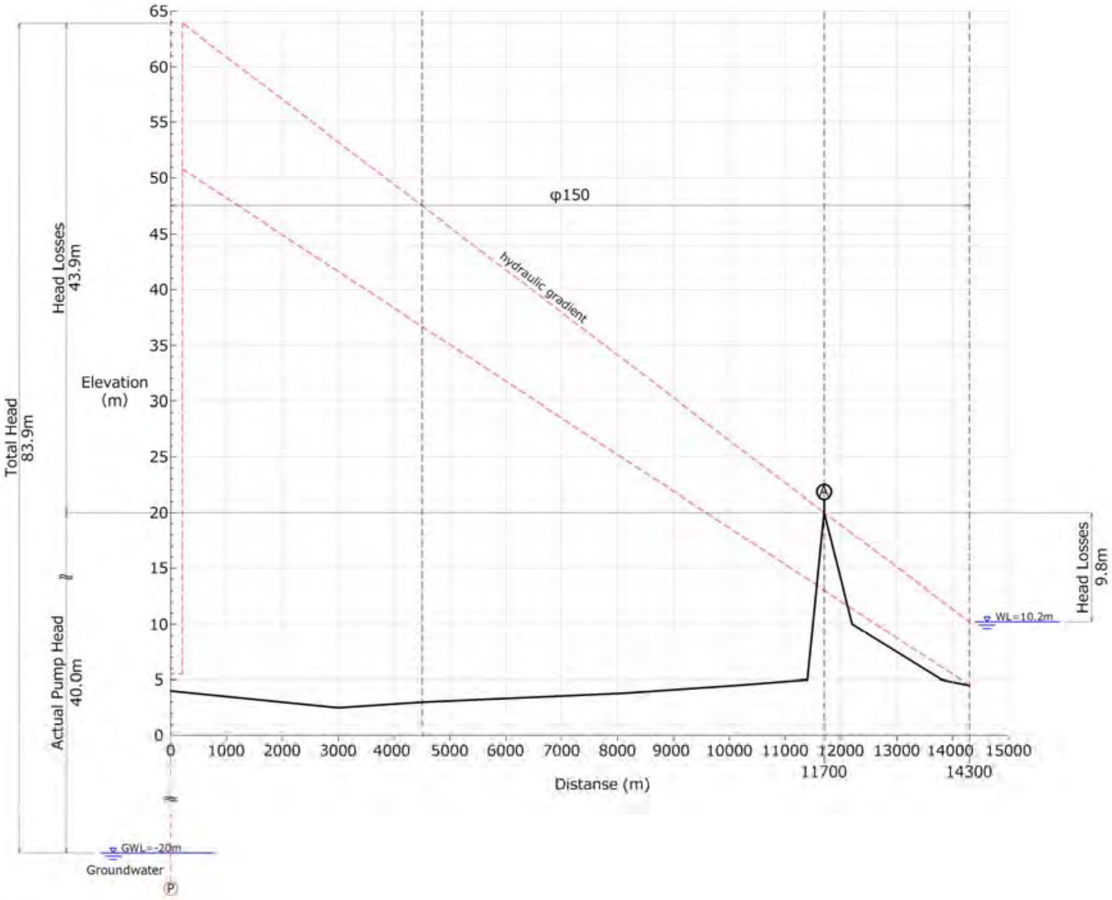


Figure 6-2-9 Hydraulic Gradient line (II New Tube Well on east plain of Thanlyin-Kyauktan Hill)

The elevation of the point of taking water on east plain is 4.0m. The number of tube wells is three, and the depth of the tube well is around 150m. And then, the groundwater level is under the ground of 20m. The location of the tube wells is referred to the result of groundwater model analysis. The collected water from the tube wells is pumped to the Thilawa SEZ by a collecting pipe.

About the total head of the well pump, there is a point of elevation of 20.0m (highest point) in the middle of the route, and the pipeline is upper the hydraulic gradient line. In this case, the water pressure becomes a negative pressure. Therefore, the elevation of the highest point is the design discharge water level, and the total head of the pump is calculated. When an air valve is set to the point, the downstream of the point becomes a gravity flow. The total head of the well pump is 83.9m by calculated as 20 m + 20.0 m + 43.9 m = 83.9 m including the head loss of the collecting pipe.

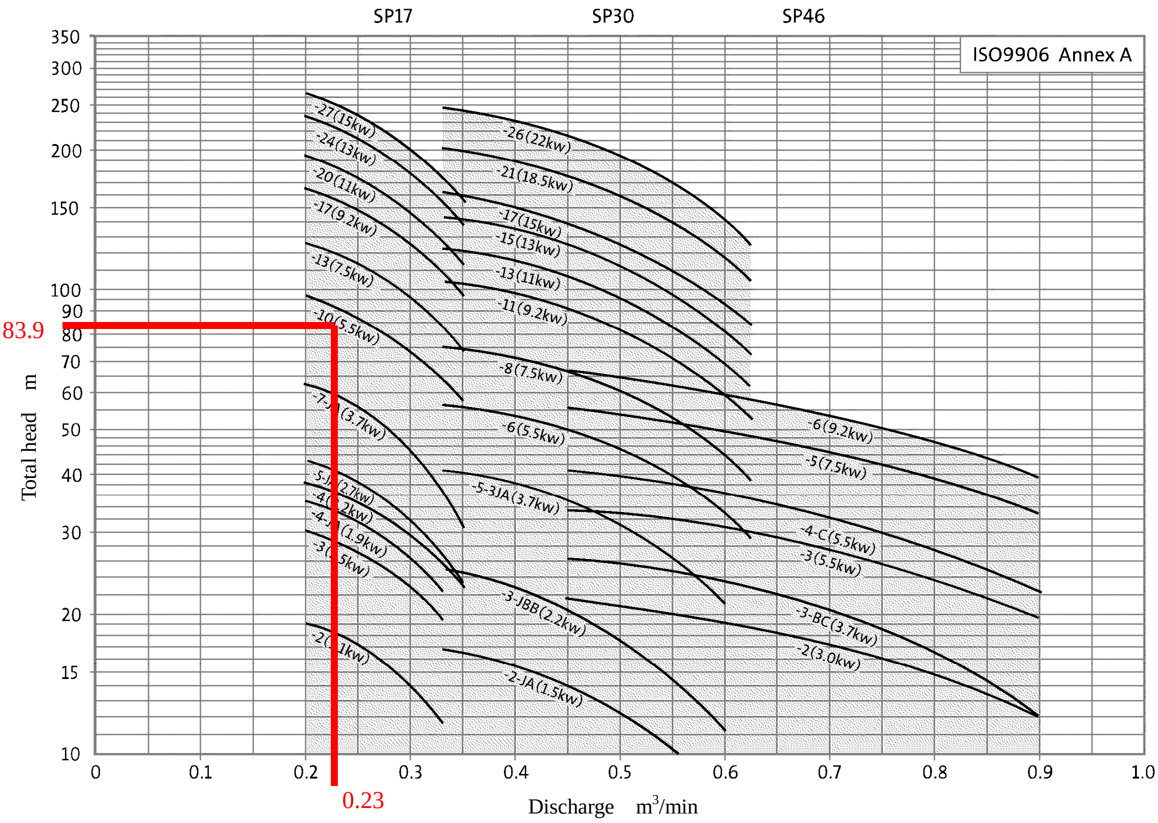


Figure 6-2-10 Performance Curve (II New Tube Well on east plain of Thanlyin-Kyauktan Hill)

Tube Well (mm)	Dia. (mm)	Model	Motor (kW)	Connection	Item				A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	Weight (kg)
					Discharge (m^3/min)	Total Head (m)	Discharge (m^3/min)	Total Head (m)						
150	50 (65) (80)	SP17-2	1.1	Flange	0.2	19	0.333	11.7	748	305	443	95	131	14.9
		SP17-3	1.5		//	30	//	19.4	849	345	504	//	//	17.5
		SP17-4-JA	1.9		//	35.4	//	22.3	1020	456	564	//	//	24
		SP17-4	2.2		//	39.4	0.35	22.6	//	//	564	//	//	//
		SP17-5-JA	2.7		//	43.7	//	23.4	1121	496	625	//	//	26
		SP17-7-JA	3.7		//	63	//	31	1322	576	746	//	//	33
		SP17-10	5.5		//	98.1	//	57.1	1508	565	943	143	142	55
		SP17-13	7.5		//	128	//	74.8	1735	610	1125	//	//	63
		SP17-17	9.2		//	166	//	97	2002	635	1367	//	//	71
		SP17-20	11		//	196	//	114	2286	738	1548	//	//	82
		SP17-24	13		//	236	//	138	2573	783	1790	//	//	91
	50 (65)	SP17-27	15		//	266	//	156	2810	838	1972	//	//	101
	65 (50) (80)	SP30-2-JA	1.5		0.333	16.8	0.6	7.7	848	345	503	95	131	17.5
		SP30-3-JBB	2.2		//	24.7	//	11.2	1055	456	599	//	//	24
		SP30-5-3JA	3.7		//	41	//	21.2	1367	576	791	//	//	33
		SP30-6	5.5		//	56.7	0.625	28.9	1468	565	903	143	142	53
		SP30-8	7.5		//	75.7	//	38.9	1705	610	1095	//	//	61
		SP30-11	9.2		//	103	//	52.5	2018	635	1383	//	//	69
		SP30-13	11		//	122	//	62.2	2313	738	1575	//	//	79
		SP30-15	13		//	142	//	73.2	2550	783	1767	//	//	88
		SP30-17	15		//	161	//	83.8	2797	838	1959	//	//	97
		SP30-21	18.5		//	200	//	105	3269	903	2366	//	//	111
		SP30-26	22		//	245	//	127	3869	1023	2846	//	//	132
	80	SP46-2	3	Rp3	0.45	21.8	0.9	12	976	496	480	95	141	25
		SP46-3-BC	3.7		//	26.3	//	12	1169	576	593	//	//	29
		SP46-3	5.5		//	33.8	//	19.8	1174	565	609	143	145	51.5
		SP46-4C	//		//	40.6	//	22.1	1287	565	722	//	//	55.5
		SP46-5	7.5		//	55.7	//	32.6	1445	610	835	//	//	60
		SP46-6	9.2		//	67.1	//	39.7	1583	635	948	//	//	65.5

Figure 6-2-11 Selection of the Pump (II New Tube Well on east plain of Thanlyin-Kyauktan Hill)

g) Result of the Consideration

Design Intake Flow	1,000m^3/day (333m^3/day × 3)
Water Resource	Deep Well (Groundwater)
Intake Facilities	Diameter of the Tube Well: 150mm, Pump: 50mm × 5.5kw × 3
	Discharge: 1,000m^3/day = 0.70m^3/min (0.23m^3/min × 3)
	Total Head: 83.9m
Water Conveyance Facilities	PVC 150mm; L = 14.3km

(3) IIIa) from Zarmani-Inn Reservoir

1) Outline of the Plan

The Zarmani-Inn Reservoir is a reservoir for agricultural purposes in east side of the Thilawa SEZ, and the water right of 6,000m^3/day for Thilawa SEZ had agreed with Ministry of Agriculture and Thilawa Management Committee. And then, it is expected by the simulation of the dam operation that the amount of 5,030m^3/day can be supplied because of the rehabilitation of the spillway and dam crest. According to the current dam operation, an irrigation water was stopped from 2013, the water from the Zarmani-Inn Reservoir is only supplied for a domestic and a navy use. In this case, the demanded water of total 10,000m^3/day from the Thirawa SEZ can be supplied physically.

The intake water from the Zarmani-Inn Reservoir is conveyed to the transfer point to the Thilawa SEZ along the road on the west side of the reservoir. The design intake water is 6,000m^3/day of which is recognized as water rights.

2) Consideration of the Facilities

a) Amount of Intake Water

Q = 6,000 m^3/day = 4.17 m^3/min = 0.070 m^3/sec

b) Target Facilities

Pumping Station, Water conveyance pipe

c) Pipe Material

DCIP300 mm

d) Pipeline Extension

L = 4.1 km = 4,100 m

e) Head loss

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 130^{-1.85} \times 0.30^{-4.87} \times 0.070^{1.85} \times 4{,}100$$
$$= 13.8m$$

where, hf : Friction Head Loss (m)

C : 130 D : 0.30 (m)

Q : 0.070 (m^3/s) L : 4,100 (m)

Head Loss H = hf ×1.3 = 13.8 m×1.3 = 17.9 m

f) Flow Velocity in Pipe

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54}$$
$$= 0.355 \times 130 \times 0.30^{0.63} \times (13.8 / 4{,}100)^{0.54}$$
$$= 1.0 m / \sec$$

Figure 6-2-12 Outline Planning (IIIa from Zarmani-Inn Reservoir)

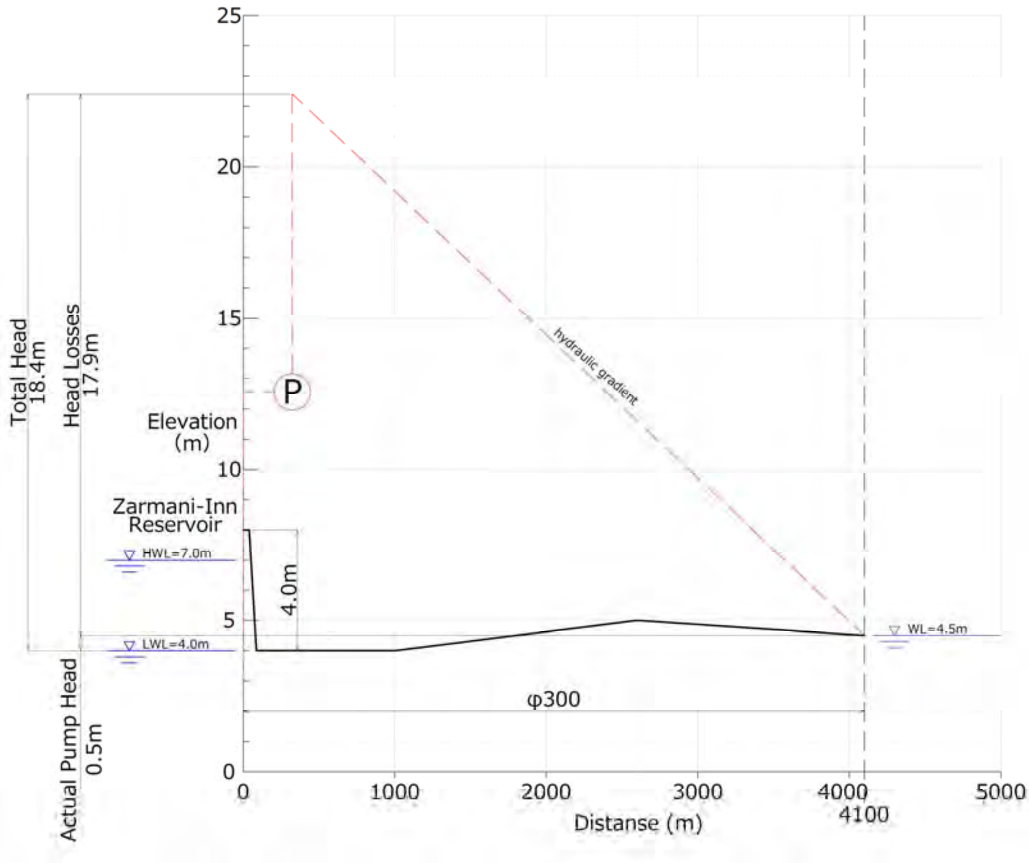


Figure 6-2-13 Hydraulic Gradient line (IIIa from Zarmani-Inn Reservoir)

A full water level of the Zarmani-Inn Reservoir is 7.0m, and a low water level is 4.0m. The elevation of the transfer point to the Thilawa SEZ is 4.5m. The head loss is 17.9m by calculating. The total head of the pump is 18.4m by calculated as 17.9 m + 0.5 m = 18.4 m with considering the difference from the Zarmani-Inn Reservoir in water level 0.5m by calculated as 4.5 - 4.0 = 0.5m.

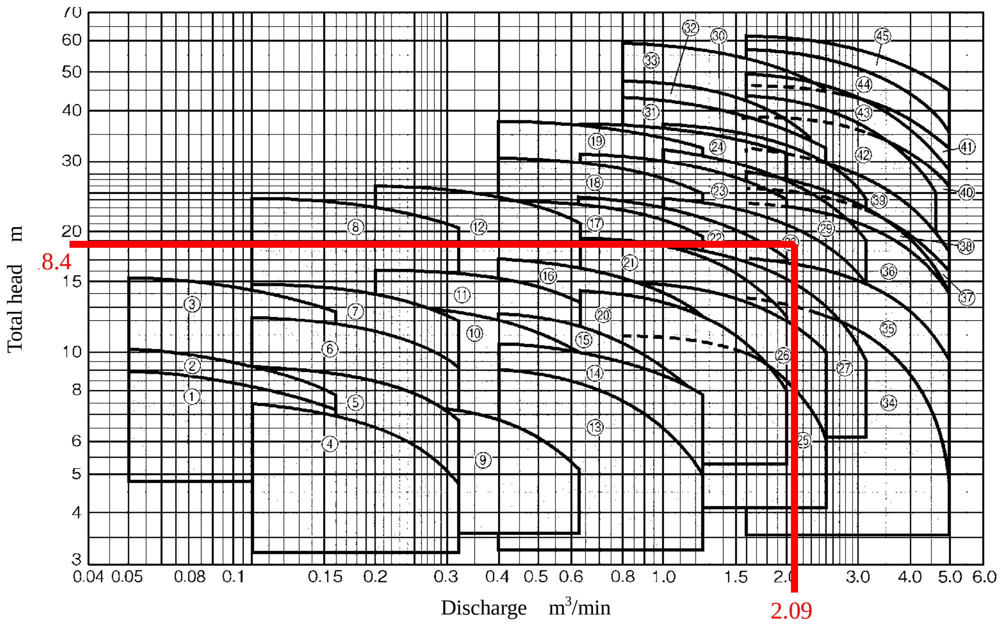


Figure 6-2-14 Performance Curve (IIIa from Zarmani-Inn Reservoir)

Dia. mm	No	Model	Motor kW	Item: Dis charge m³/min	Item: Total Head m	Item: Dis charge m³/min	Item: Total Head m	Item: Dis charge m³/min	Item: Total Head m	Allowable Pressure MPa { f/ }
40 × 32	1	GEJ-40×325M-4MN0.4	0.4	0.05	9	0.1	8.2	0.16	7.2	0.88 {9.0}
	2	GEK-40×325M-4MN0.4	0.4	0.05	10.2	0.1	9.2	0.16	7.8	0.86 {8.8}
	3	GEK-405M-4MN0.75	0.75	0.05	15.2	0.1	14.2	0.16	12.5	0.81 {8.3}
50 × 40	4	GEJ-50×405M-4MN0.4	0.4	0.1	7.5	0.2	6.5	0.32	4.8	0.89 {9.1}
	5	GEJ-505M-4MN0.75	0.75	0.1	9.2	0.2	8.5	0.32	6.8	0.88 {9.0}
	6	GEK-505M-4MN0.75	0.75	0.1	12.2	0.2	11.2	0.32	9.2	0.85 {8.7}
	7	GEK-505M-4MN1.5	1.5	0.1	14.8	0.2	14	0.32	12	0.82 {8.4}
	8	GEL-505M-4MN2.2	2.2	0.1	24.2	0.2	23	0.32	20.5	0.73 {7.4}
65 × 50	9	GEJ-655M-4MN0.75	0.75	0.2	8	0.4	6.8	0.63	5.2	0.89 {9.1}
	10	GEK-655M-4MN1.5	1.5	0.2	13	0.4	12	0.63	10	0.84 {8.6}
	11	GEK-655M-4MN2.2	2.2	0.2	16	0.4	15.2	0.63	13.2	0.8 {8.2}
	12	GEL-655M-4MN3.7	3.7	0.2	26	0.4	24.5	0.63	21	0.72 {7.3}
80 × 65	13	GEJ-805M-4MN1.5	1.5	0.4	9	0.8	7.5	1.25	5	0.87 {8.9}
	14	GEJ-805M-4MN2.2	2.2	0.4	10.5	0.8	9.5	1.25	7.8	0.86 {8.8}
	15	GEK-805M-4MN2.2	2.2	0.4	12.5	0.8	10.5	1.25	7.5	0.84 {8.6}
	16	GEK-805M-4MN3.7	3.7	0.4	17	0.8	15.2	1.25	12.2	0.79 {8.1}
	17	GEL-805M-4MN5.5	5.5	0.4	24.2	0.8	22.5	1.25	19.2	0.74 {7.5}
	18	GEM-805M-4MN7.5	7.5	0.4	30.5	0.8	28.5	1.25	24.5	0.68 {6.9}
	19	GEM-805M-4MN11	11	0.4	38	0.8	36	1.25	32	0.6 {6.1}
100 × 80	20	GEK-1005M-4MN3.7	3.7	0.63	14.2	1.25	12.2	2.0	8	0.85 {8.7}
	21	GEL-1005M-4MN5.5	5.5	0.63	19.2	1.25	17.2	2.0	12.2	0.78 {8.0}
	22	GEL-1005M-4MN7.5	7.5	0.63	24	1.25	21.5	2.0	17	0.75 {7.6}
	23	GEM-1005M-4MN11	11	0.63	31	1.25	29	2.0	24	0.69 {7.0}
	24	GEM-1005M-4MN15	15	0.63	37	1.25	35.5	2.0	31	0.62 {6.3}
125 × 100	25	GEK-1255M-4MN3.7	3.7	0.8	11.8	1.6	10	2.5	6.2	0.84 {8.6}
	26	GEK-1255M-4MN5.5	5.5	0.8	15	1.6	13.5	2.5	10	0.81 {8.3}
	27	GEL-1255BM-4MN7.5	7.5	1.0	18.5	2.0	15.2	3.1	10	0.80 {8.2}
	28	GEL-1255BM-4MN11	11	1.0	24	2.0	21	3.15	15.5	0.76 {7.7}
	29	GEM-1255BM-4MN15	15	1.0	32	2.0	27	3.15	19.5	0.66 {6.7}
	30	GEM-1255BM-4M18	18.5	1.0	37	2.0	32.5	3.15	24	0.62 {6.3}
	31	GEM-125×1005M-4M18	18.5	0.8	42.5	1.6	38.5	2.5	30.8	0.55 {5.6}
	32	GEO-1255M-4M22	22	0.8	47	1.6	42	2.5	31.5	0.52 {5.3}
	33	GEO-1255M-4M30	30	0.8	59	1.6	54.5	2.5	45	0.41 {4.2}

Figure 6-2-15 Selection of the Pump (IIIa from Zarmani-Inn Reservoir)

g) Result of the Consideration

Design Intake Flow	6,000m^3/day
Water Resource	Zarmani-Inn Reservoir (Surface Water)
Intake Facilities	Volute Pump: 125mm × 11kw × 2
	Discharge: 6,000m^3/day = 2.09m^3/min × 2
	Total Head: 18.4m
Water Conveyance Facilities	DCIP 300mm; L = 4.1km

(4) IIIb) from Zarmani-Inn Reservoir

1) Outline of the Plan

In this case, the design intake flow is 10,000m^3/day compared with IIIa.

2) Consideration of the Facilities

a) Amount of Intake Water

Q = 10,000 m^3/day = 6.94 m^3/min = 0.116 m^3/sec

b) Target Facilities

Pumping Station, Water conveyance pipe

c) Pipe Material

DCIP400 mm

d) Pipeline Extension

L = 4.1 km = 4,100 m

e) Head loss

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 130^{-1.85} \times 0.40^{-4.87} \times 0.116^{1.85} \times 4{,}100$$
$$= 8.7m$$

where, hf : Friction Head Loss (m)

C : 130 D : 0.40 (m)

Q : 0.116 (m^3/s) L : 4,100 (m)

Head Loss H = hf ×1.3 = 8.7 m×1.3 = 11.3 m

f) Flow Velocity in Pipe

$$
\begin{aligned}
V &= 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54} \\
&= 0.355 \times 130 \times 0.40^{0.63} \times (8.7 / 4{,}100)^{0.54} \\
&= 0.9 m / \sec
\end{aligned}
$$

Figure 6-2-16　Outline Planning (IIIb from Zarmani-Inn Reservoir)

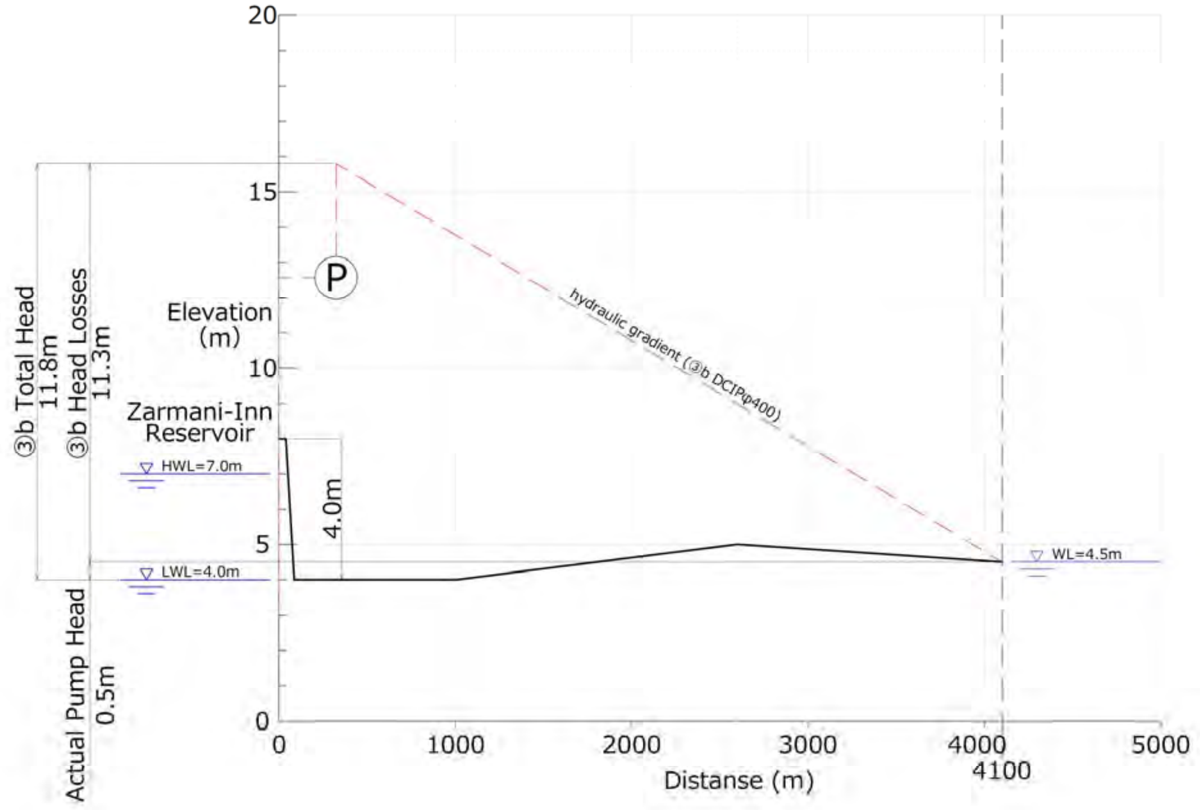


Figure 6-2-17 Hydraulic Gradient line (IIIb from Zarmani-Inn Reservoir)

A full water level of the Zarmani-Inn Reservoir is 7.0m, and a low water level is 4.0m. The elevation of the transfer point to the Thilawa SEZ is 4.5m. The head loss is 11.3m by calculating. The total head of the pump is 11.8m by calculated as 11.3 m + 0.5 m = 11.8 m with considering the difference from the Zarmani-Inn Reservoir in water level 0.5m by calculated as 4.5 - 4.0 = 0.5m.

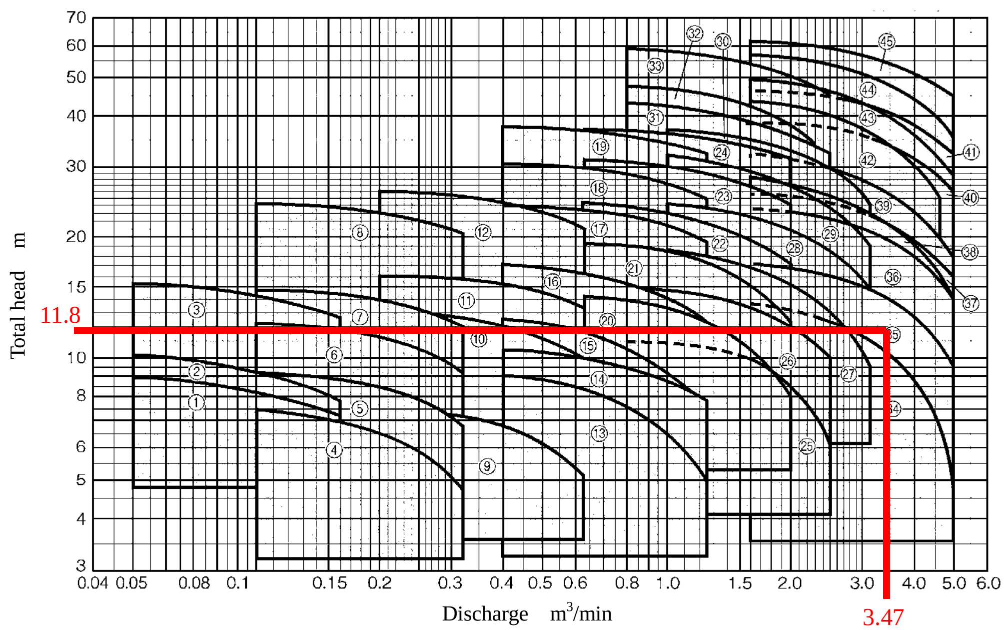


Figure 6-2-18 Performance Curve (IIIb from Zarmani-Inn Reservoir)

Dia. mm	No	Model	Motor kW	Item: Dis charge m³/min	Total Head m	Dis charge m³/min	Total Head m	Dis charge m³/min	Total Head m	Allowable Pressure MPa{ f/ }
40×32	1	GEJ-40×325M-4MN0.4	0.4	0.05	9	0.1	8.2	0.16	7.2	0.88 {9.0}
	2	GEK-40×325M-4MN0.4	0.4	0.05	10.2	0.1	9.2	0.16	7.8	0.86 {8.8}
	3	GEK-405M-4MN0.75	0.75	0.05	15.2	0.1	14.2	0.16	12.5	0.81 {8.3}
50×40	4	GEJ-50×405M-4MN0.4	0.4	0.1	7.5	0.2	6.5	0.32	4.8	0.89 {9.1}
	5	GEJ-505M-4MN0.75	0.75	0.1	9.2	0.2	8.5	0.32	6.8	0.88 {9.0}
	6	GEK-505M-4MN0.75	0.75	0.1	12.2	0.2	11.2	0.32	9.2	0.85 {8.7}
	7	GEK-505M-4MN1.5	1.5	0.1	14.8	0.2	14	0.32	12	0.82 {8.4}
	8	GEL-505M-4MN2.2	2.2	0.1	24.2	0.2	23	0.32	20.5	0.73 {7.4}
65×50	9	GEJ-655M-4MN0.75	0.75	0.2	8	0.4	6.8	0.63	5.2	0.89 {9.1}
	10	GEK-655M-4MN1.5	1.5	0.2	13	0.4	12	0.63	10	0.84 {8.6}
	11	GEK-655M-4MN2.2	2.2	0.2	16	0.4	15.2	0.63	13.2	0.8 {8.2}
	12	GEL-655M-4MN3.7	3.7	0.2	26	0.4	24.5	0.63	21	0.72 {7.3}
80×65	13	GEJ-805M-4MN1.5	1.5	0.4	9	0.8	7.5	1.25	5	0.87 {8.9}
	14	GEJ-805M-4MN2.2	2.2	0.4	10.5	0.8	9.5	1.25	7.8	0.86 {8.8}
	15	GEK-805M-4MN2.2	2.2	0.4	12.5	0.8	10.5	1.25	7.5	0.84 {8.6}
	16	GEK-805M-4MN3.7	3.7	0.4	17	0.8	15.2	1.25	12.2	0.79 {8.1}
	17	GEL-805M-4MN5.5	5.5	0.4	24.2	0.8	22.5	1.25	19.2	0.74 {7.5}
	18	GEM-805M-4MN7.5	7.5	0.4	30.5	0.8	28.5	1.25	24.5	0.68 {6.9}
	19	GEM-805M-4MN11	11	0.4	38	0.8	36	1.25	32	0.6 {6.1}
100×80	20	GEK-1005M-4MN3.7	3.7	0.63	14.2	1.25	12.2	2.0	8	0.85 {8.7}
	21	GEL-1005M-4MN5.5	5.5	0.63	19.2	1.25	17.2	2.0	12.2	0.78 {8.0}
	22	GEL-1005M-4MN7.5	7.5	0.63	24	1.25	21.5	2.0	17	0.75 {7.6}
	23	GEM-1005M-4MN11	11	0.63	31	1.25	29	2.0	24	0.69 {7.0}
	24	GEM-1005M-4MN15	15	0.63	37	1.25	35.5	2.0	31	0.62 {6.3}
125×100	25	GEK-1255M-4MN3.7	3.7	0.8	11.8	1.6	10	2.5	6.2	0.84 {8.6}
	26	GEK-1255M-4MN5.5	5.5	0.8	15	1.6	13.5	2.5	10	0.81 {8.3}
	27	GEL-1255BM-4MN7.5	7.5	1.0	18.5	2.0	15.2	3.1	10	0.80 {8.2}
	28	GEL-1255BM-4MN11	11	1.0	24	2.0	21	3.15	15.5	0.76 {7.7}
	29	GEM-1255BM-4MN15	15	1.0	32	2.0	27	3.15	19.5	0.66 {6.7}
	30	GEM-1255BM-4M18	18.5	1.0	37	2.0	32.5	3.15	24	0.62 {6.3}
	31	GEM-125×1005M-4M18	18.5	0.8	42.5	1.6	38.5	2.5	30.8	0.55 {5.6}
	32	GEO-1255M-4M22	22	0.8	47	1.6	42	2.5	31.5	0.52 {5.3}
	33	GEO-1255M-4M30	30	0.8	59	1.6	54.5	2.5	45	0.41 {4.2}
150×125	34	GEK-1505M-4MN7.5	7.5	1.6	13.5	3.15	11	5.0	4.8	0.85 {8.7}
	35	GEK-1505M-4MN11	11	1.6	17.2	3.15	14.8	5.0	9.5	0.82 {8.4}
	36	GEL-1505M-4MN15	15	1.6	23.5	3.15	20.8	5.0	13.5	0.76 {7.8}
	37	GEL-1505M-4M18	18.5	1.6	25.2	3.15	22.5	5.0	16	0.75 {7.6}
	38	GEM-1505M-4M18	18.5	1.6	28	3.15	23	5.0	13.5	0.69 {7.0}
	39	GEM-1505M-4M22	22	1.6	32	3.15	27.5	5.0	17.5	0.65 {6.6}
	40	GEM-1505M-4M30	30	1.6	39	3.15	35	5.0	26	0.58 {5.9}
	41	GEM-1505M-4M37	37	1.6	45.5	3.15	42.5	5.0	32	0.51 {5.2}
	42	GEO-1505M-4M30	30	1.6	44.5	3.15	36.5	4.6	25	0.54 {5.5}
	43	GEO-1505M-4M37	37	1.6	49.5	3.15	42.5	5.0	28	0.49 {5.0}
	44	GEO-1505M-4M45	45	1.6	56.5	3.15	50	5.0	35	0.42 {4.3}
	45	GEO-1505M-4M55	55	1.6	61	3.15	56	5.0	45	0.38 {3.9}

Figure 6-2-19 Selection of the Pump (IIIb from Zarmani-Inn Reservoir)

g) Result of the Consideration

Design Intake Flow: 10,000m^3/day

Water Resource: Zarmani-Inn Reservoir (Surface Water)

Intake Facilities: Volute Pump: 150mm × 11kw × 2

Discharge: 10,000m^3/day = 3.47m^3/min × 2

Total Head: 11.8m

Water Conveyance Facilities: DCIP 400mm; L = 4.1km

(5) IV) from Ban Bwe Gon Reservoir

1) Outline of the Plan

The ban Bwe Gon Reservoir is a reservoir for agricultural purposes in southeast side of the Thilawa SEZ. It is expected by the simulation of the dam operation that the amount of 2,900m^3/day can be supplied. However, the reservoir can't cover by itself the amount of water demanded for the Thilawa SEZ. Therefore, it is the backup water resource as a Short-Term. The intake water from the Ban Bwe Gon Reservoir is conveyed to the transfer point to the Thilawa SEZ along the main road.

The water right is not negotiated at this time. If the water in the drought year is supplied to the Thilawa SEZ, there is some anxiety, which is expected to be frowned upon from existing persons with water right.

2) Consideration of the Facilities

a) Amount of Intake Water

Q = 2,900 m^3/day = 2.01 m^3/min = 0.034 m^3/sec

b) Target Facilities

Pumping Station, Water conveyance pipe

c) Pipe Material

PVC200 mm

d) Pipeline Extension

L = 4.3 km = 4,300 m

e) Head loss

$$\begin{aligned} hf &= 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L \\ &= 10.67 \times 150^{-1.85} \times 0.20^{-4.87} \times 0.034^{1.85} \times 4300 \\ &= 21.0m \end{aligned}$$

Head Loss H = hf ×1.3 = 21.0m×1.3 = 27.3 m

f) Flow Velocity in Pipe

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54} = 0.355 \times 200 \times 0.15^{0.63} \times (21.0/4{,}300)^{0.54} = 1.1m/\sec$$

Figure 6-2-20 Outline Planning (IV from Ban Bwe Gon Reservoir)

A full water level of the Ban Bwe Gon Reservoir is 7.9m, and a low water level is 4.7m. There is a point of elevation of 20.0m (highest point) in the middle of the route, but the pipeline is under the hydraulic gradient line. The elevation of the transfer point to the Thilawa SEZ is 4.5m.

The head loss is 27.6m in this case. The total head of the pump is 27.6m because the elevation of the transfer point of the Thilawa SEZ is lower than the lower water level of the Ban Bwe Gon Reservoir.

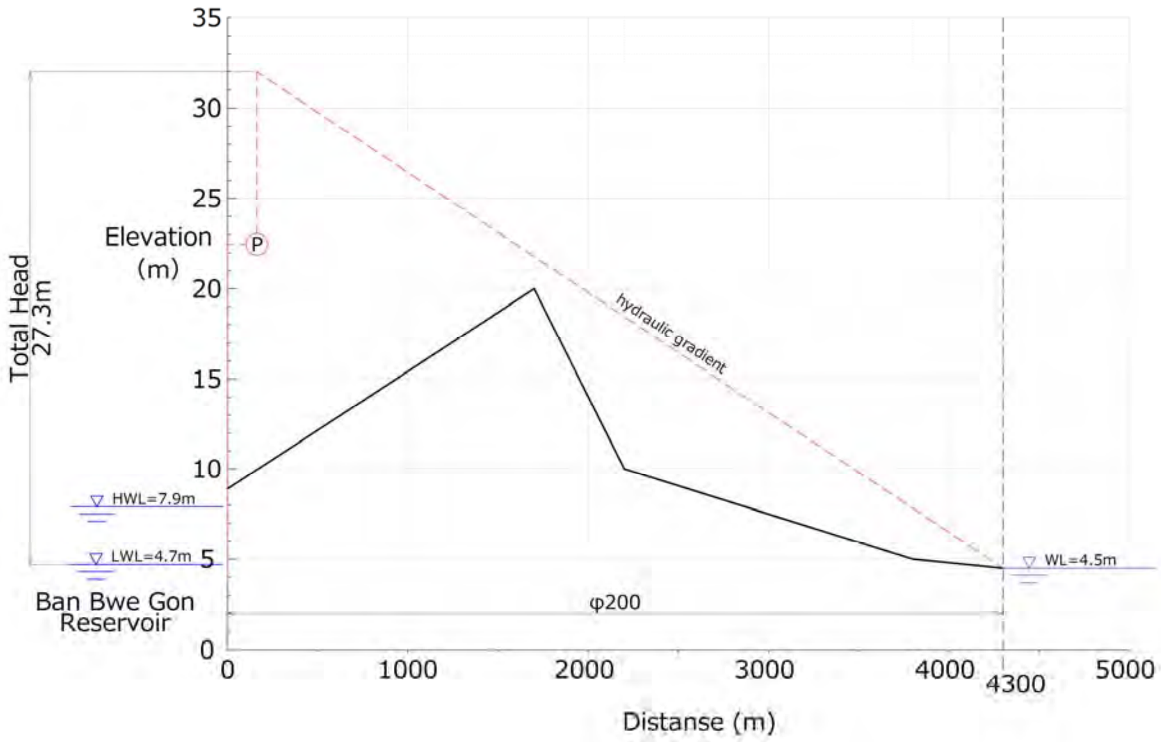


Figure 6-2-21 Hydraulic Gradient line (IV from Ban Bwe Gon Reservoir)

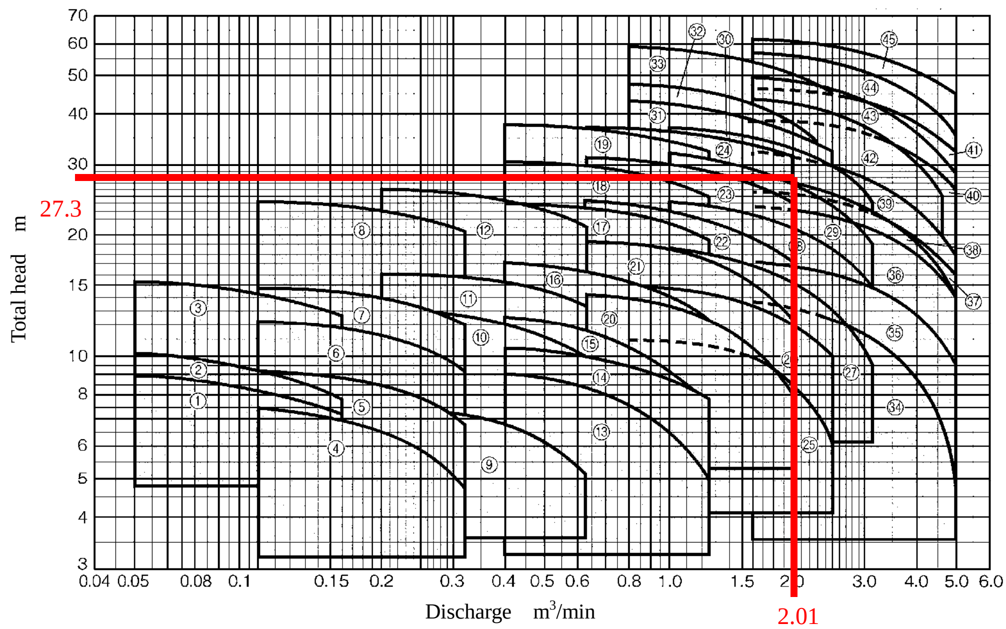


Figure 6-2-22 Performance Curve (IV from Ban Bwe Gon Reservoir)

Dia. mm	No	Model	Motor kW	Item: Dis charge m³/min	Item: Total Head m	Item: Dis charge m³/min	Item: Total Head m	Item: Dis charge m³/min	Item: Total Head m	Allowable Pressure MPa { f/ }
40 × 32	1	GEJ-40×325M-4MN0.4	0.4	0.05	9	0.1	8.2	0.16	7.2	0.88 {9.0}
	2	GEK-40×325M-4MN0.4	0.4	0.05	10.2	0.1	9.2	0.16	7.8	0.86 {8.8}
	3	GEK-405M-4MN0.75	0.75	0.05	15.2	0.1	14.2	0.16	12.5	0.81 {8.3}
50 × 40	4	GEJ-50×405M-4MN0.4	0.4	0.1	7.5	0.2	6.5	0.32	4.8	0.89 {9.1}
	5	GEJ-505M-4MN0.75	0.75	0.1	9.2	0.2	8.5	0.32	6.8	0.88 {9.0}
	6	GEK-505M-4MN0.75	0.75	0.1	12.2	0.2	11.2	0.32	9.2	0.85 {8.7}
	7	GEK-505M-4MN1.5	1.5	0.1	14.8	0.2	14	0.32	12	0.82 {8.4}
	8	GEL-505M-4MN2.2	2.2	0.1	24.2	0.2	23	0.32	20.5	0.73 {7.4}
65 × 50	9	GEJ-655M-4MN0.75	0.75	0.2	8	0.4	6.8	0.63	5.2	0.89 {9.1}
	10	GEK-655M-4MN1.5	1.5	0.2	13	0.4	12	0.63	10	0.84 {8.6}
	11	GEK-655M-4MN2.2	2.2	0.2	16	0.4	15.2	0.63	13.2	0.8 {8.2}
	12	GEL-655M-4MN3.7	3.7	0.2	26	0.4	24.5	0.63	21	0.72 {7.3}
80 × 65	13	GEJ-805M-4MN1.5	1.5	0.4	9	0.8	7.5	1.25	5	0.87 {8.9}
	14	GEJ-805M-4MN2.2	2.2	0.4	10.5	0.8	9.5	1.25	7.8	0.86 {8.8}
	15	GEK-805M-4MN2.2	2.2	0.4	12.5	0.8	10.5	1.25	7.5	0.84 {8.6}
	16	GEK-805M-4MN3.7	3.7	0.4	17	0.8	15.2	1.25	12.2	0.79 {8.1}
	17	GEL-805M-4MN5.5	5.5	0.4	24.2	0.8	22.5	1.25	19.2	0.74 {7.5}
	18	GEM-805M-4MN7.5	7.5	0.4	30.5	0.8	28.5	1.25	24.5	0.68 {6.9}
	19	GEM-805M-4MN11	11	0.4	38	0.8	36	1.25	32	0.6 {6.1}
100 × 80	20	GEK-1005M-4MN3.7	3.7	0.63	14.2	1.25	12.2	2.0	8	0.85 {8.7}
	21	GEL-1005M-4MN5.5	5.5	0.63	19.2	1.25	17.2	2.0	12.2	0.78 {8.0}
	22	GEL-1005M-4MN7.5	7.5	0.63	24	1.25	21.5	2.0	17	0.75 {7.6}
	23	GEM-1005M-4MN11	11	0.63	31	1.25	29	2.0	24	0.69 {7.0}
	24	GEM-1005M-4MN15	15	0.63	37	1.25	35.5	2.0	31	0.62 {6.3}
125 × 100	25	GEK-1255M-4MN3.7	3.7	0.8	11.8	1.6	10	2.5	6.2	0.84 {8.6}
	26	GEK-1255M-4MN5.5	5.5	0.8	15	1.6	13.5	2.5	10	0.81 {8.3}
	27	GEL-1255BM-4MN7.5	7.5	1.0	18.5	2.0	15.2	3.1	10	0.80 {8.2}
	28	GEL-1255BM-4MN11	11	1.0	24	2.0	21	3.15	15.5	0.76 {7.7}
	29	GEM-1255BM-4MN15	15	1.0	32	2.0	27	3.15	19.5	0.66 {6.7}
	30	GEM-1255BM-4M18	18.5	1.0	37	2.0	32.5	3.15	24	0.62 {6.3}
	31	GEM-125×1005M-4M18	18.5	0.8	42.5	1.6	38.5	2.5	30.8	0.55 {5.6}
	32	GEO-1255M-4M22	22	0.8	47	1.6	42	2.5	31.5	0.52 {5.3}
	33	GEO-1255M-4M30	30	0.8	59	1.6	54.5	2.5	45	0.41 {4.2}
150 × 125	34	GEK-1505M-4MN7.5	7.5	1.6	13.5	3.15	11	5.0	4.8	0.85 {8.7}
	35	GEK-1505M-4MN11	11	1.6	17.2	3.15	14.8	5.0	9.5	0.82 {8.4}
	36	GEL-1505M-4MN15	15	1.6	23.5	3.15	20.8	5.0	13.5	0.76 {7.8}
	37	GEL-1505M-4M18	18.5	1.6	25.2	3.15	22.5	5.0	16	0.75 {7.6}
	38	GEM-1505M-4M18	18.5	1.6	28	3.15	23	5.0	13.5	0.69 {7.0}
	39	GEM-1505M-4M22	22	1.6	32	3.15	27.5	5.0	17.5	0.65 {6.6}
	40	GEM-1505M-4M30	30	1.6	39	3.15	35	5.0	26	0.58 {5.9}
	41	GEM-1505M-4M37	37	1.6	45.5	3.15	42.5	5.0	32	0.51 {5.2}
	42	GEO-1505M-4M30	30	1.6	44.5	3.15	36.5	4.6	25	0.54 {5.5}
	43	GEO-1505M-4M37	37	1.6	49.5	3.15	42.5	5.0	28	0.49 {5.0}
	44	GEO-1505M-4M45	45	1.6	56.5	3.15	50	5.0	35	0.42 {4.3}
	45	GEO-1505M-4M55	55	1.6	61	3.15	56	5.0	45	0.38 {3.9}

Figure 6-2-23 Selection of the Pump (IV from Ban Bwe Gon Reservoir)

g) Result of the Consideration

Design Intake Flow: 2,900m^3/day

Water Resource: Ban Bwe Gon Reservoir (Surface Water)

Intake Facilities: Volute Pump: 150mm × 22kw × 1

Discharge: 2,900m^3/day = 2.01m^3/min

Total Head: 27.3m

Water Conveyance Facilities: PVC 200mm; L = 4.3km

(6) V) New Reservoir Construction in the Thilawa SEZ area

1) Outline of the Plan

It is planned new reservoirs inside the Thilawa SEZ as the additional water resource. Because the elevation inside the Thilawa SEZ is around 5.0m, there may be affected by salt water intrusion when excavating ground to ensure the effective depth. Therefore, the reservoir is constructed only by laying earth on the ground without excavation. The reservoir is requested the water depth of 2.5m and the area of 700,000m^3 by the simulation result. 700,000m^3 is the amount of water that can ensure the additional water of 4,000m^3/day The location of the reservoirs is selected a position which is close to the Thilawa SEZ main road and Class A, and also outside of the Class A.

In the neighborhood, there are some reservoirs which have 30acre storage in Thongwa and Khayan. The water right is no problem because it is new reservoir. It is expected to ensure the reservoir area as much as possible in view of the evapotranspiration of the reservoir in dry season.

2) Consideration of the Facilities

a) Amount of Intake Water

Total storage capacity; Q = 1,800,000 m^3 (600 m×600 m×2.5m×2)

b) Target Facilities

Reservoir

c) Dimension

Reservoir area: 600 m×600 m×Hight 3.6m ×2

d) Dam Body Material

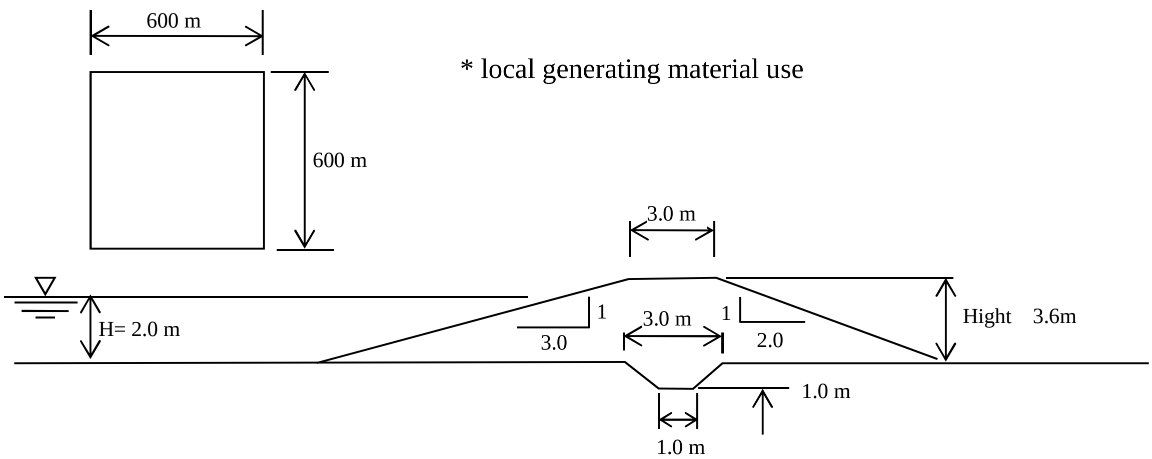


Figure 6-2-24 Plan and Cross Section (V New Reservoir Construction in the Thilawa SEZ area)

Figure 6-2-25 Outline Planning (V New Reservoir Construction in the Thilawa SEZ area)

e) Result of the Consideration

Design Intake Flow	Total 1,800,000m^3
Water Resource	Rain Water
Water Storage Facilities	600m × 600m, H = 3.6m × 2

(7) VIa) from Khayan River

1) Outline of the Plan

In the current situation of the 30 miles greening project, main canal has already constructed, and the flow test is carrying out to the Khayan river as a water source (Kodugwe Dam, Shwe Laung Dam, Salu Dam) the dams of three places that have been built in western tributary of the Bago River (started from December 19, 2013). The demanded water for irrigation is the amount of around 493 MCM of water is required. On the other hand, the cross-sectional area of flow of the main canal in the 30 miles greening project is 42.5 m^3/sec, and the amount of 4,000 m^3/day for the short-term is 0.1% of the capacity.

Figure 6-2-26 Main Canal of 30 Miles Greening Project

In order to ensure the irrigation water required by 30 miles greening project, it is necessary to construct a Dawei Dam in addition to the three above-mentioned dam. The water right is not negotiated at this time, and it is a precondition to construct the Dawei Dam in this plan.

The water quality at the taking water point of the Khayan River is high electrical conductivity (EC), in other words, it is supposed a tendency with much dissolved salt. On the other hand, around 16 times of the demanded water is flowed when full-scale flow is started, and then, it is expected that the salinity is greatly reduced.

The selected pipeline route is a shortest distance along the main road in the route from Khayan River to the Thilawa SEZ. Because the pipeline extension from the Khayan River to the Thilawa SEZ is so long, the booster pumping station is necessary on the way of the route. Therefore, a consideration of water hammer is required separately.

2) Consideration of the Facilities

a) Amount of Intake Water

Q = 4,000 m^3/day = 2.78 m^3/min = 0.046 m^3/sec

b) Target Facilities

Intake, Pumping station (2 places), Storage tank, Water conveyance pipe (2 Sections)

c) Pipe Material

Section 1: PVC250 mm
Section 2: PVC250 mm

d) Pipeline Extension

L = 24.6 km = 24,600 m
Section 1: Pumping station 1 - Storage tank, L1 = 13,300m
Section 2: Pumping station 1 - Thilawa SEZ, L2 = 11,300m

e) Head loss

Section 1: Pumping station 1 - Storage tank, L1 = 13,300m

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 150^{-1.85} \times 0.25^{-4.87} \times 0.046^{1.85} \times 13{,}300$$
$$= 38.4m$$

Head Loss H = hf ×1.3 = 38.4m×1.3 = 49.9 m

from Pumping station 2 to highest pointin the pipeline in Section 2, L = 8,700m

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 150^{-1.85} \times 0.25^{-4.87} \times 0.046^{1.85} \times 8{,}700$$
$$= 25.1m$$

Head Loss H = hf ×1.3 = 25.1m×1.3 = 32.6m

from highest pointin the pipeline to the Thilawa SEZ in Section 2, L = 2,600m

$$hf = 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$
$$= 10.67 \times 150^{-1.85} \times 0.25^{-4.87} \times 0.046^{1.85} \times 2{,}600$$
$$= 7.5m$$

Head Loss H = hf ×1.3 = 7.5m×1.3 = 9.8 m

f) Flow Velocity in Pipe

Section 1: Pumping station 1 - Storage tank

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54} = 0.355 \times 150 \times 0.25^{0.63} \times (38.4/13{,}300)^{0.54} = 0.9m/\sec$$

from Pumping station 2 to highest pointin the pipeline in Section 2

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54} = 0.355 \times 150 \times 0.25^{0.63} \times (25.1/8{,}700)^{0.54} = 0.9m/\sec$$

The elevation of around intake point of the Khayan River is 4.0m. The water level of the river is a seasonal variation, and it varies between -1.0m and 3.0m. In this plan, an intake is installed to the Khayan River, and the river water is pumped to the Thilawa SEZ. There is a point of elevation of 20.0m (highest point) in the middle of the route. Because the pipeline extension from the Khayan River to the Thilawa SEZ is so long, a friction loss of the pipeline is dominant when the standard of the pump and pipe are selected. Because the amount of pump discharge is smaller than the length of the extension of the pipe, the pump with a little load is selected by installing the pumping station near the middle point of the route.

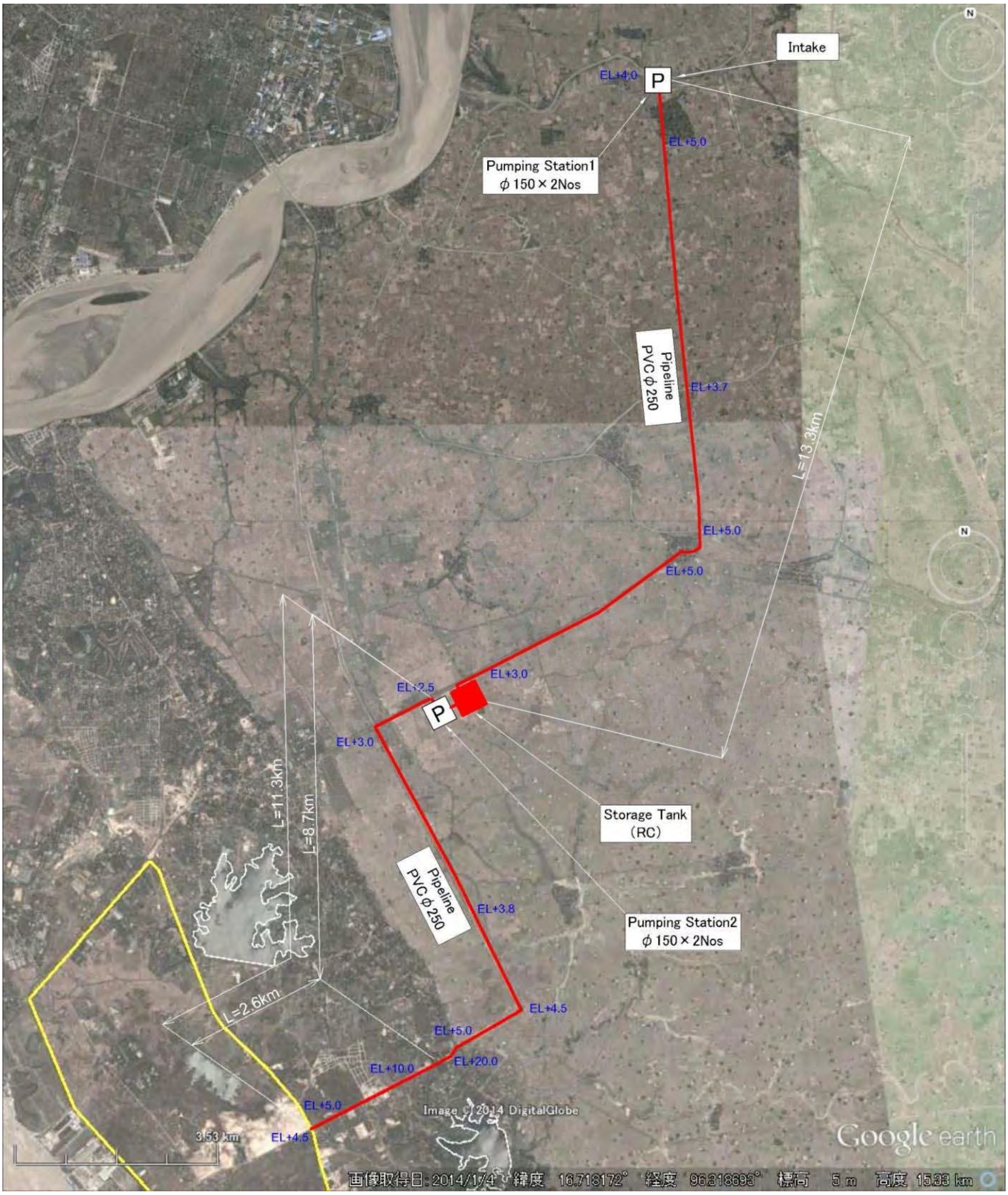


Figure 6-2-27　Outline Planning (VIa from Khayan River)

In the Section 2, because the highest point in the middle of the pipeline route is upper the hydraulic gradient line, the water pressure becomes a negative pressure. Therefore, the elevation of the highest point is the design discharge water level, and the total head of the pump is calculated. When an air valve is set to the point, the downstream of the point becomes a gravity flow.

In the Section 1, the total head of the pump is 51.4m by calculated as 1.5 m + 49.9 m = 51.4 m including the head loss of the collecting pipe. And also, the total head of the pump is 50.1m by calculated as 17.5 m + 32.6 m = 50.1 m in the section from highest point of the pipeline to the Thilawa SEZ in the Section 2.

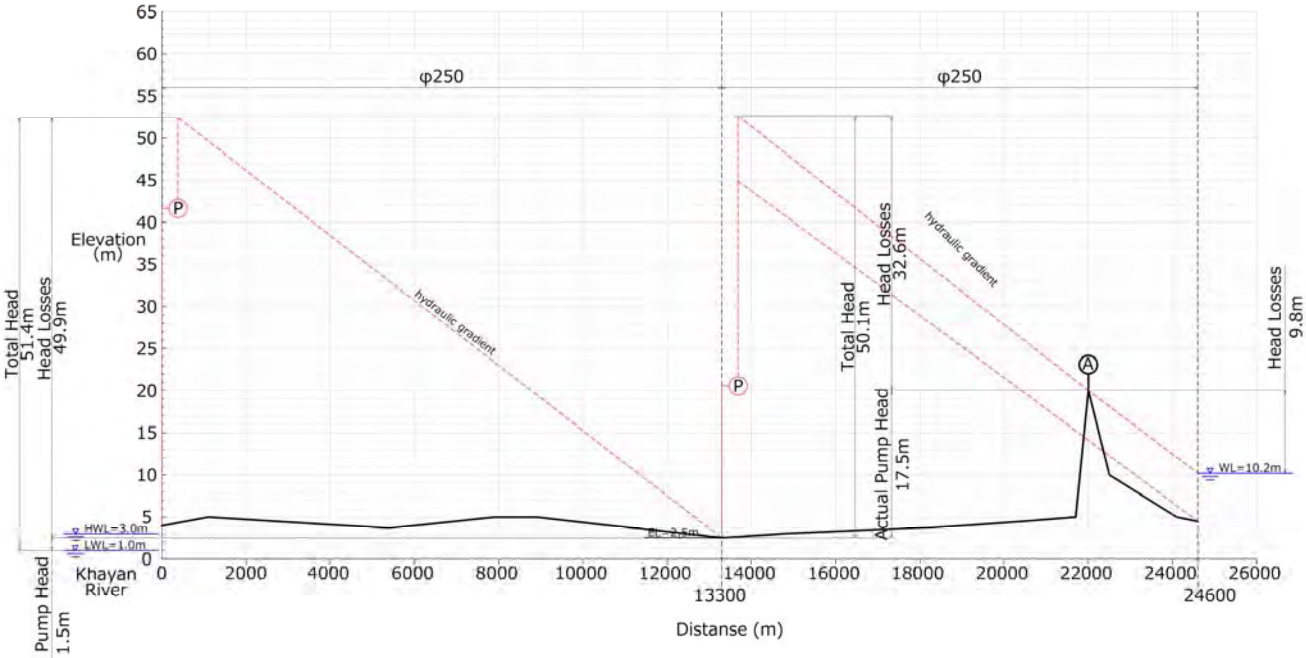
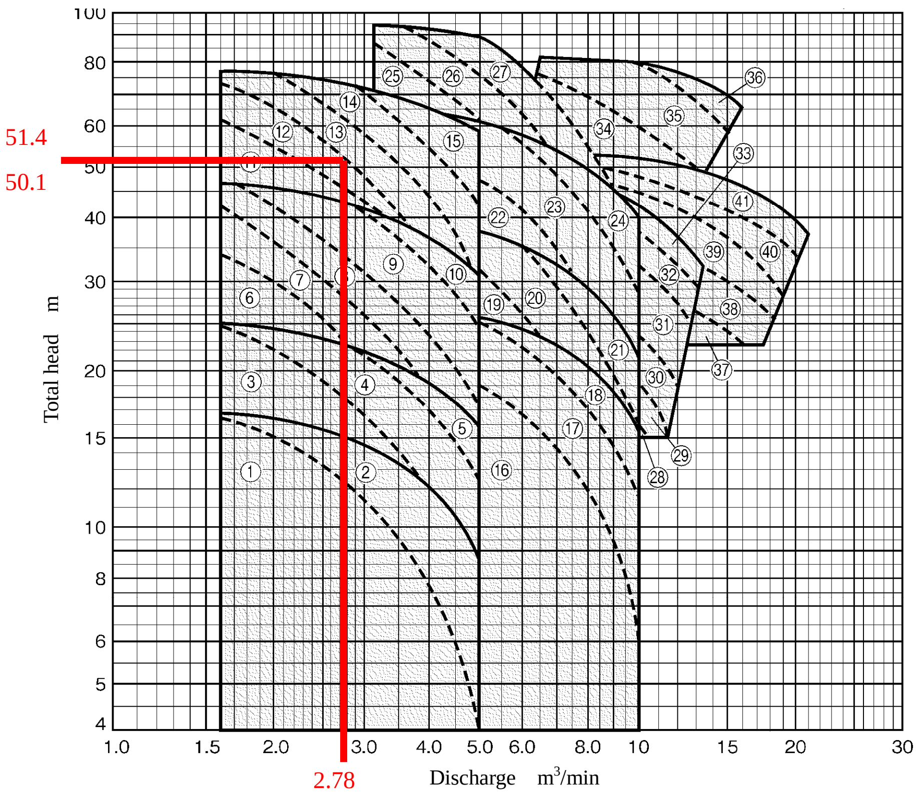


Figure 6-2-28 Hydraulic Gradient Line (VIa from Khayan River)



Dia. ㎜	No	Model	Motor ㎾
150 × 125	1	GFK-1505-4MN7.5	7.5
	2	GFK-1505-4MN11	11
	3	GFL-1505-4MN11	11
	4	GFL-1505-4MN15	15
	5	GFL-150×1255-4M18.5	18.5
	6	GFM-1505-4MN15	15
	7	GFM-150×1255-4M18.5	18.5
	8	GFM-150×1255-4M22	22
	9	GFM-150×1255-4M30	30
	10	GFM-150×1255-4M37	37
	11	GFO-150×1255-4M30	30
	12	GFO-150×1255-4M37	37
	13	GFO-150×1255-4M45	45
	14	GFO-150×1255-4M55	55
	15	GFO-150×1255-4M75	75

Figure 6-2-29 Performance Curve and Pump Selection
(VIa from Khayan River)

g) Result of the Consideration

Design Intake Flow	4,000m^3/day
Water Resource	Upstream Bago Dams (Surface Water)
Intake Facilities	Intake: RC, 1Place
Intake Facilities	Volute Pump: 150mm × 37kw × 1Nos, 2Places
	Discharge: 4,000m^3/day = 2.78m^3/min
	Total Head: 51.4m, 50.1m (2Sections)
Water Storage Facilities	RC, Effective Storage: 4,000m^3
Water Conveyance Facilities	PVC 250mm; L = 24.6km (2Sections)

(8) VIb) from Khayan River (information)

In the Long-Term plan, the amount of 120,000m^3/day is required for the full development of the Thilawa SEZ. The water resources which can be supplied the water demand for future are only 4 dams of existing dams (Kodugwe Dam, Shwe Laung Dam, Salu Dam) and Dawei Dam which is being planned, there are controlled by MOAI. Therefore, it is a realistic and economic plan to take water from Khayan River by using the main canal of the 30 miles greening project, like the Short-Term plan.

On the other hand, it does not deny the possibility to be introduced the water sources mentioned in "6-1-2 Other Water Resources" in the future.

1) Outline of the Plan

In this case, the design intake flow is 290,000m^3/day compared with VIa.

2) Consideration of the Facilities

a) Amount of Intake Water

Q = 120,000 m^3/day = 83.3 m^3/min = 1.389 m^3/sec

b) Target Facilities

Intake, Pumping station, Water conveyance pipe (2 Sections)

c) Pipe Material

DCIP1,100 mm

d) Pipeline Extension

L = 24.6 km = 24,600 m

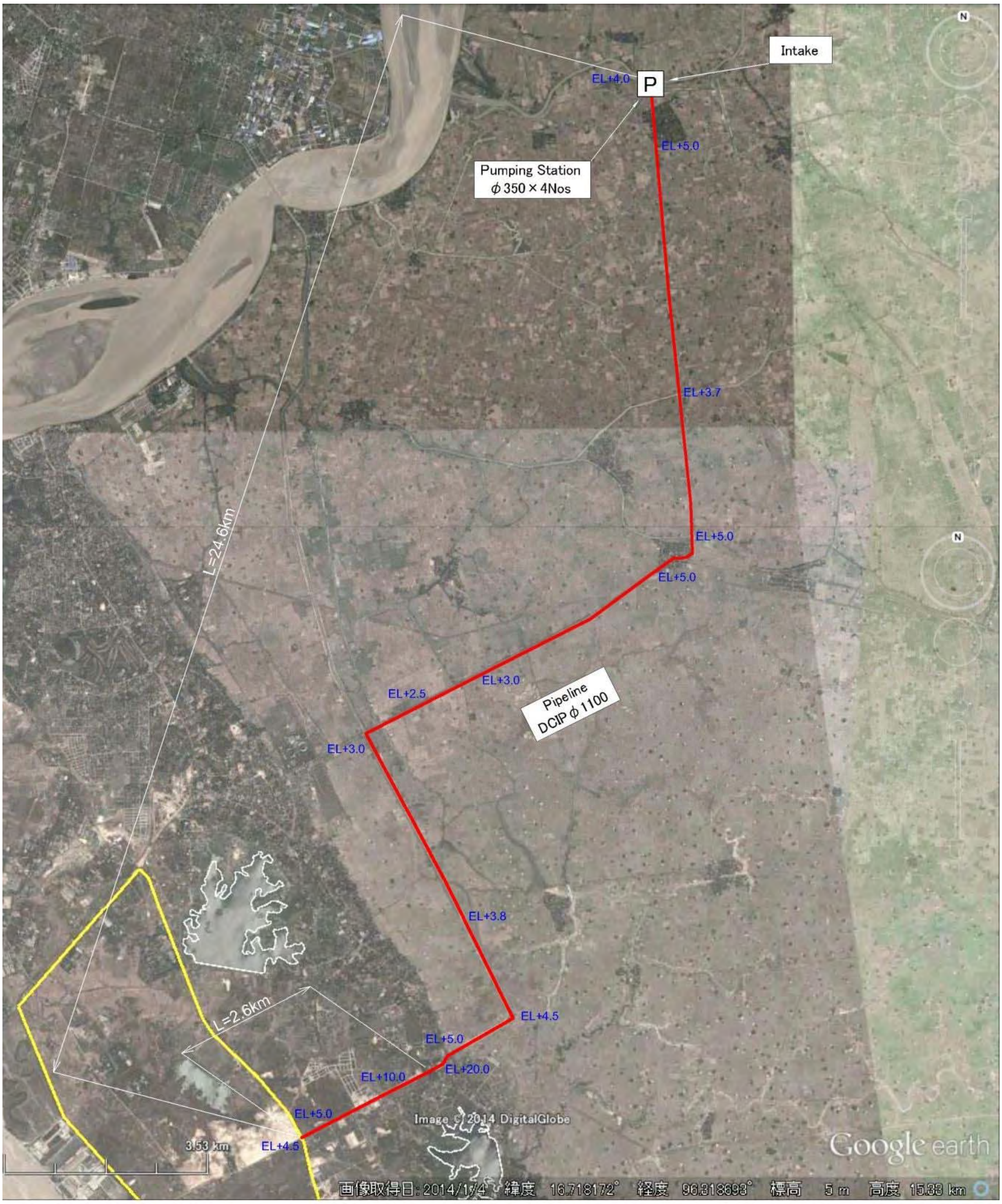


Figure 6-2-30 Outline Planning (VIb from Khayan River)

e) Head loss

from pumping station to the highest point of the pipeline, L = 22,000 m

$$
\begin{aligned}
hf &= 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L \\
&= 10.67 \times 130^{-1.85} \times 1.10^{-4.87} \times 1.389^{1.85} \times 22{,}000 \\
&= 33.3m
\end{aligned}
$$

Head Loss H = hf ×1.3 = 33.3m×1.3 = 43.3 m

from the highest point of the pipeline to the Thilawa SEZ, L = 2,600 m

$$
\begin{aligned}
hf &= 10.67 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L \\
&= 10.67 \times 130^{-1.85} \times 1.10^{-4.87} \times 1.389^{1.85} \times 2{,}600 \\
&= 3.9m
\end{aligned}
$$

Head Loss H = hf ×1.3 = 3.9m×1.3 = 5.1 m

f) Flow Velocity in Pipe

from pumping station to the highest point of the pipeline

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54} = 0.355 \times 130 \times 1.10^{0.63} \times (33.3/22{,}000)^{0.54} = 1.5m/\sec$$

from the highest point of the pipeline to the Thilawa SEZ

$$V = 0.355 \cdot C \cdot D^{0.63} \cdot I^{0.54} = 0.355 \times 130 \times 1.10^{0.63} \times (3.9/2{,}600)^{0.54} = 1.5m/\sec$$

The elevation of around intake point of the Khayan River is 4.0m. The water level of the river is a seasonal variation, and it varies between -1.0m and 3.0m. In this plan, an intake is installed to the Khayan River, and the river water is pumped to the Thilawa SEZ. There is a point of elevation of 20.0m (highest point) in the middle of the route. Because the pipeline extension from the Khayan River to the Thilawa SEZ is so long, a friction loss of the pipeline is dominant when the standard of the pump and pipe are selected.

Because the highest point in the middle of the pipeline route is upper the hydraulic gradient line, the water pressure becomes a negative pressure. Therefore, the elevation of the highest point is the design discharge water level, and the total head of the pump is calculated. When an air valve is set to the point, the downstream of the point becomes a gravity flow.

The total head of the pump is 62.3m by calculated as (20.0 m - 1.0 m) + 43.3 m = 62.3 m including the head loss of the collecting pipe.

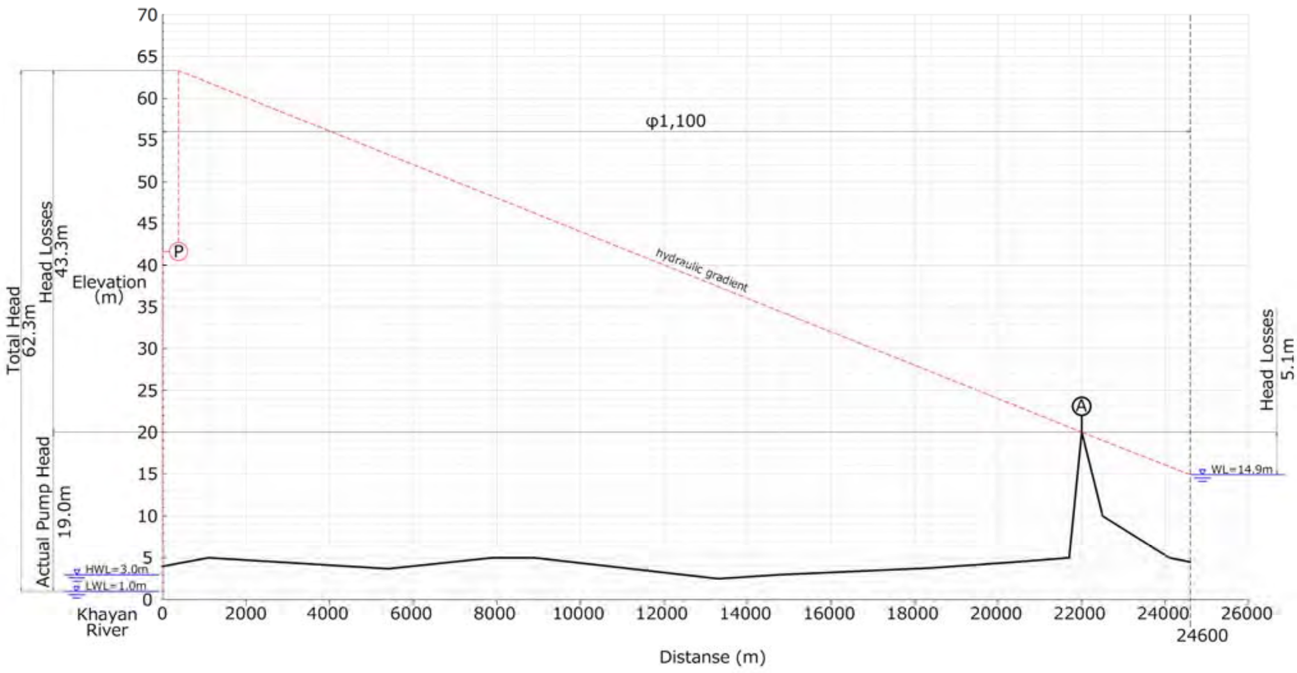


Figure 6-2-32 Hydraulic Gradient line (VIb from Khayan River)

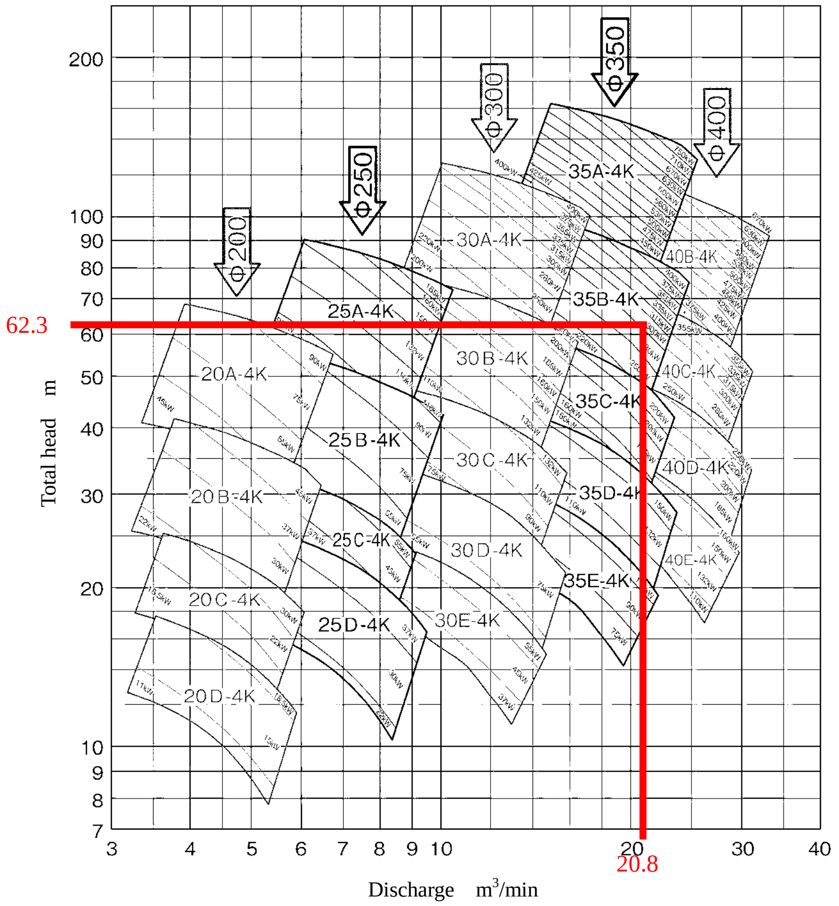


Figure 6-2-31 Performance Curve (VIb from Khayan River)

Model	Motor (kW)	Pole	Ds	Dd	A	C	E	F	EDs	EDd	H	PH	G	L	BN	BW	NN	Weight (kg)
35A-4K	400	4	350	200	590	750	650	510	355	400	805	1311	12	2974	2400	922	370	3580
	425~630	4	350	200	590	750	650	510	355	400	855	1361	12	3242	2720	922	380	4560
	670~750	4	350	200	590	750	650	510	355	400	855	1361	14	3404	2850	934	380	5220
35B-4K	220,250	4	350	200	560	720	565	415	335	335	735	1161	10	2707	2030	774	360	2490
	280~400	4	350	200	560	720	565	415	335	335	735	1161	12	2914	2340	792	370	3090
35C-4K	150,160	4	350	200	510	655	520	415	310	310	710	1068	10	2341	1920	774	360	1830
	185~220	4	350	200	510	655	520	415	310	310	710	1068	10	2592	1960	774	360	2130
35D-4K	110	4	350	250	480	620	450	415	295	295	595	920	10	2186	1780	774	350	1240
	132	4	350	250	480	620	450	415	295	295	645	970	10	2186	1870	774	360	1340
	150	4	350	250	480	620	450	415	295	295	645	970	10	2276	1870	774	360	1480
35E-4K	75	4	350	250	460	590	435	415	280	280	580	880	4	1986	1640	774	350	1060
	90	4	350	250	460	590	435	415	280	280	580	880	4	1986	1680	774	350	1090
	110	4	350	250	460	590	435	415	280	280	580	880	10	2136	1750	774	350	1160
40B-4K	355~400	4	400	250	570	730	610	455	365	365	815	1276	12	2934	2400	852	400	3370
	425~630	4	400	250	570	730	610	455	365	365	865	1326	12	3202	2730	822	410	4340
	670	4	400	250	570	730	610	455	365	365	865	1326	14	3364	2860	934	410	5020
40C-4K	250	4	400	250	530	675	565	455	340	340	740	1130	10	2632	2010	834	390	2330
	280~355	4	400	250	530	675	565	455	340	340	790	1180	12	2839	2350	852	400	2890
40D-4K	185~250	4	400	300	510	645	555	455	320	320	720	1074	10	2582	1980	834	390	2140
40E-4K	110	4	400	300	480	610	475	455	310	310	660	989	10	2176	1820	834	380	1290
	132	4	400	300	480	610	475	455	310	310	660	989	10	2176	1880	834	380	1370
	150,160	4	400	300	480	610	475	455	310	310	660	989	10	2266	1880	834	380	1650

Figure 6-2-33 Selection of the Pump (VIb from Khayan River)

g) Result of the Consideration

Design Intake Flow	120,000m^3/day
Water Resource	Upstream Bago Dams (Surface Water)
Intake Facilities	Intake: RC, 1Place
Intake Facilities	Volute Pump: 350mm × 300kw × 4Nos
	Discharge: 120,000m^3/day = 20.8m^3/min× 4
	Total Head: 62.3m
Water Conveyance Facilities	DCIP 1,100mm; L = 24.6km

6-2-2 Cost Comparison

For the Short-Term plan, a cost comparison is carried out by the calculation of initial and running cost.

The initial cost is estimated in reference to “Guidance on Accounting for Renewal Cost of the Facilities regarding Reconstruction of Water Supply Business (in Jan 2011, Ministry of Health, Labour and Welfare Department of Health Water Supply Division)”. The reference is for accounting for the new and/or renewal cost of the water facilities by using a cost function created from the actual cost survey in Japan, and it is an initial construction cost in the case of performing the construction by the Japanese contractor in Japan only.

For the running cost, a durable years of each facility is as follows. A Life Cycle Cost (LCC), excluding a risk assessment, is considered as one (1) cycle in fifty (50) years.

- civil and architectural structures: 50 years
- pumping facilities: 18 years
- pipeline facilities: 40 years

The civil structures (concrete) have the durability more than 50 years. Therefore, it isn't necessary to consider the running cost for a 1 cycle period. The architectural structure is the same as it.

A power cost (electric power cost) is allocated as the running cost for the pumping facilities. Moreover, the maintenance cost is expected about one hundred thousand yen per year with considering a periodic maintenance, but it is difficult to determine whether maintenance is carried out.

For the pipeline facilities, the pipe has the serviceability limit more than 50 years. On the other hand, the durable years is adopted 40 years from the point of view of legal durable years by considering the degradation of a pipe fitting and inner lining.

The result of the cost estimation is shown as follows.

Table 6-2-1 Result of Estimation

Water Resource	available water (m^3/day)	Cost Estimation (million yen)		
		(1) initial cost	(2) running cost (per year)	(3) LCC (50 years)
I) New Tube Well in the Thilawa SEZ area	1,000	230	1.2	677
II) New Tube Well on east plain of Thanlyin-Kyauktan Hill	1,000	473	1.7	1,228
IIIa) from Zarmani-Inn Reservoir	6,000	498	2.3	1,094
IIIb) from Zarmani-Inn Reservoir	10,000	582	2.3	1,261
IV) from Ban Bwe Gon Reservoir	2,900	375	2.3	850
V) New Reservoir Construction in the Thilawa SEZ area	4,000	1,736	0	1,736
VI) from Khayan River	4,000	1,470	12.4	2,787

The most economical plan for initial cost is "I New Tube Well in the Thilawa SEZ area". "I" is also most economical even if compare the LCC, but it is limited to emergency use only. As the permanent water resource for the short-term, it is found that "IIIa from Zarmani-Inn Reservoir" is the economical plan.

In II and VI, it is necessary to convey the water over the Thanlyin-Kyauktan Hill of the east side of the Thilawa SEZ, and the pumping facilities and the storage tank are necessary. Therefore, these facilities become the reason of the high costs. The reason why VI is so high in particular is due to the long extension of the pipeline.

On the other hand, the result of the cost evaluation is as shown in Table 6-2-2. In this section, a cost-effectiveness is evaluated with using total cost (Initial + Running) per one cubic meter (1m^3) for LCC.

IIIb is most cost-effectiveness. The location of the water resource is near the Thilawa SEZ, and the amount of intake water is expected. Because a part of the water right is allowed, it is up to the operating method of the Zarmani-Inn Reservoir whether the full amount of the demanded water for short-term is able to supply.

IIIa is effective next to IIIb. It is realistic plan including allowed a part of the water right. V is also effective, but it is not necessary to ensure the land for water resource reducing the land of the Thilawa SEZ. The water resource should be selected elsewhere. IV is better to assume as the back up of III.

The remaining plan of I, II and VI are not cost-effectiveness. I and II have pales in comparison to the other plans because of limited to emergency use only.

Table 6-2-2 Cost Evaluation

Water Resource	LCC (50 yeas) (a)	available water (m^3/day) (b)	evaluation		
			(a)/(b)	Ratio for comparison	order of economy
I) New Tube Well in the Thilawa SEZ area	677	1,000	0.677	3.7	5
II) New Tube Well on east plain of Thanlyin-Kyauktan Hill	1,228	1,000	1.228	6.7	7
IIIa) from Zarmani-Inn Reservoir	1,094	6,000	0.182	1.0	2
IIIb) from Zarmani-Inn Reservoir	1,261	10,000	0.126	0.7	1
IV) from Ban Bwe Gon Reservoir	850	2,900	0.293	1.6	3
V) New Reservoir Construction in the Thilawa SEZ area	1,736	4,000	0.434	2.4	4
VI) from Khayan River	2,787	4,000	0.697	3.8	6

As the result of the evaluation, “IIIa/ IIIb for Zarmani-Inn Reservoir” is most reasonable plan for the short-term.

(1) New Tube Well in the Thilawa SEZ area

1) Initial Cost

(a) Deep Well

(φ150、Depth 100m 、φ50mm × 7.5 kw × 3)

convert from amount of intake water as 5% of water loss

x： capacity of purification plant x＝ 333 m^3/day per place

y： construction cost (×10^3 yen)

- scope of application: civil work (construction cost per depth)

y＝ 0.0924 × 333 ＋ 109.8009

＝ 141 (×10^3 yen)

cost of civil work

＝ 141 × 100m × 3

＝ 42,300 (×10^3 yen)

＝ 42 (×10^6 yen)

- scope of application: machinery work (construction cost per depth)

y＝ 0.0137 × 333 ＋ 68.6098

＝ 73 (×10^6 yen)

cost of machinery work

＝ 73 × 100m × 3

＝ 21,900 (×10^3 yen)

＝ 22 (×10^6 yen)

- scope of application: electrical work

y＝ 0.012 × 333 ＋ 15.2747

＝ 19 (×10^6 yen)

cost of electrical work

＝ 19 × 3

＝ 57 (×10^6 yen)

Total cost of deep well ＝ 42+22＋57

＝ <u>121</u> (×10^6 yen)

(b) Pipeline

(PVC φ150 mm、L＝ 4,200 m)

x : extension x = 4,200 m

y : construction cost (×10^4 yen)

- scope of application: no pavement, daytime construction

y = 2.6 × 4,200

= 10,920 (×10^4 yen)

= <u>109</u> (×10^6 yen)

Estimation

(a) + (b)

= 121 + 109

= <u>230</u> (×10^6 yen)

= 2,300,000 (US$)

2) Running Cost

<u>Pump</u>	motor	3.7	kw
	number of pump	3	Nos
	operating time	12	hr/day

<u>Contracti</u> 14 kw

Power = 3.7 kw × 3 × 1.25

= 13.875 (kw)

<u>Basic Rate</u>	in Tokyo	1,101.6	(yen/kw)
	discount	5	(%)

Basic Rate = 14 kw × 1,101.6 yen/kw × 0.95

= 14,651 (yen/month)

<u>Utility Rate</u> in Tokyo 15.42 (yen/kw・H)

Utility Rate = 13.875 kw × 12 hr/day × 15.42 yen/kw・H × 30 days

= 77022.9 (yen/month)

Power Rate   Basic Rate ＋ Utility Rate

＝ 14,651 ＋ 77022.9

＝ 91,674 (yen/month)

＝ 1.1 (10^6yen/year)

Running Cost   1.1 ＋ 0.1 ＝ 1.2 (10^6yen/year)

3) LCC

(a) Pumping Station

Civil	42	(×10^6 yen)	durability: 50years
Machine and Electric	79	(×10^6 yen)	durability: 18years
Running cost	1.2	(×10^6 yen /year)	1.1＋0.1

(b) Pipeline

PVC	109	(×10^6 yen)	durability: 40years

LCC： 42×1＋79×3＋1.2×50×3＋109×2

＝ 677 (×10^6 yen /50years)

(2) II) New Tube Well on east plain of Thanlyin-Kyauktan Hill

1) Initial Cost

(a) Deep Well

(φ150、Depth 150m 、φ50mm × 13.0 kw × 3)

convert from amount of intake water as 5% of water loss

x： capacity of purification plant   x＝ 333 m^3/day per place

y： construction cost (×10^3 yen)

- scope of application: civil work (construction cost per depth)

y＝ 0.0924 × 333 ＋ 109.8009

＝ 141 (×10^3 yen)

cost of civil work

＝ 141 × 150m × 3

= 63,450 ($\times 10^3$ yen)
= 63 ($\times 10^6$ yen)

- scope of application: machinery work (construction cost per depth)

y = 0.0137 × 333 + 68.6098
= 73 ($\times 10^6$ yen)

cost of machinery work
= 73 × 150m × 3
= 32,850 ($\times 10^3$ yen)
= 33 ($\times 10^6$ yen)

- scope of application: electrical work

y = 0.012 × 333 + 15.2747
= 19 ($\times 10^6$ yen)

cost of electrical work
= 19 × 3
= 57 ($\times 10^6$ yen)

Total cost of deep well = 63+33+57
= <u>153</u> ($\times 10^6$ yen)

(b) Pipeline

(PVC φ150 mm、L = 12,300 m)

x : extension x = 12,300 m
y : construction cost ($\times 10^4$ yen)

- scope of application: no pavement, daytime construction

y = 2.6 × 12,300
= 31,980 ($\times 10^4$ yen)
= <u>320</u> ($\times 10^6$ yen)

Estimation

(a) + (b)
= 153 + 320
= <u>473</u> ($\times 10^6$ yen)
= 4,730,000 (US$)

2) Running Cost

Pump	motor	5.5	kw
	number of pump	3	Nos
	operating time	12	hr/day

Contracti 21 kw

Power = 5.5 kw × 3 × 1.25
= 20.625 (kw)

Basic Rate	in Tokyo	1,101.6	(yen/kw)
	discount	5	(%)

Basic Rate = 21 kw × 1,101.6 yen/kw × 0.95
= 21,976 (yen/month)

Utility Rate in Tokyo 15.42 (yen/kw・H)

Utility Rate = 20.625 kw × 12 hr/day × 15.42 yen/kw・H × 30 days
= 114493.5 (yen/month)

Power Rate Basic Rate ＋ Utility Rate
= 21,976 ＋ 114493.5
= 136,470 (yen/month)
= 1.6 (10^6yen/year)

Running Cost 1.6 ＋ 0.1 = 1.7 (10^6yen/year)

3) LCC

(a) Pumping Station

Civil	63	(×10^6 yen)	durability: 50years
Machine and Electric	90	(×10^6 yen)	durability: 18years
Running cost	1.7	(×10^6 yen /year)	1.6＋0.1

(b) Pipeline

PVC 320 (×10^6 yen) durability: 40years

LCC： 63×1＋90×3＋1.7×50×3＋320×2
＝ 1,228 (×10^6 yen /50years)

(3) IIIa) from Zarmani-Inn Reservoir

1) Initial Cost

(a) Pumping Station
(φ125mm × 11.0 kw × 2 Nos)

Punping Station (outside)
x： discharge x＝ 6,000 m^3/day
y： construction cost (×10^6 yen)

- scope of application: civil work (construction cost per depth)
y＝ 0.0056 × 6,000 ＋ 119.1249
＝ 153 (×10^6 yen)

- scope of application: machinery work
y＝ 0.0034 × 6,000 ＋ 25.8517
＝ 46 (×10^6 yen)

- scope of application: electrical work
y＝ 0.0019 × 6,000 ＋ 78.1407
＝ 90 (×10^6 yen)

Total cost of pumping station ＝ 153+46＋90
＝ 289 (×10^6 yen)

(b) Pipeline
(DCIP φ300 mm、L＝ 4,100 m)

x： extension x＝ 4,100 m

y： construction cost (×10^4 yen)

- scope of application: no pavement, daytime construction

y ＝ 5.1 × 4,100

＝ 20,910 (×10^4 yen)

＝ 209 (×10^6 yen)

Estimation

(a) + (b)

= 289 + 209

= 498 (×10^6 yen)

= 4,980,000 (US$)

2) Running Cost

Pump	motor	11	kw
	number of pump	2	Nos
	operating time	12	hr/day

Contracti 28 kw

Power ＝ 11 kw × 2 × 1.25

＝ 27.5 (kw)

Basic Rate	in Tokyo	1,101.6	(yen/kw)
	discount	5	(%)

Basic Rate ＝ 28 kw × 1,101.6 yen/kw × 0.95

＝ 29,302 (yen/month)

Utility Rate	in Tokyo	15.42	(yen/kw･H)

Utility Rate ＝ 27.5 kw × 12 hr/day × 15.42 yen/kw･H × 30 days

＝ 152658 (yen/month)

Power Rate Basic Rate ＋ Utility Rate

＝ 29,302 ＋ 152658

＝ 181,960 (yen/month)

＝ 2.2 (10^6yen/year)

Running Cost 2.2 ＋ 0.1 = 2.3 (10^6yen/year)

3) LCC

(a) Pumping Station

Civil	153	(×10^6 yen)	durability: 50years
Machine and Electric	136	(×10^6 yen)	durability: 18years
Running cost	2.3	(×10^6 yen /year)	2.2＋0.1

(b) Pipeline

DCIP	209	(×10^6 yen)	durability: 40years

LCC： 153×1＋136×3＋2.3×50＋209×2

＝ 1,094 (×10^6 yen /50years)

(4) IIIb) from Zarmani-Inn Reservoir

1) Initial Cost

(a) Pumping Station

(φ150mm × 11.0 kw × 2 Nos)

Punping Station (outside)

x： discharge x＝ 10,000 m^3/day

y： construction cost (×10^6 yen)

- scope of application: civil work (construction cost per depth)

y＝ 0.0056 × 10,000 ＋ 119.1249

＝ 175 (×10^6 yen)

- scope of application: machinery work

y＝ 0.0034 × 10,000 ＋ 25.8517

= 60 ($\times 10^6$ yen)

- scope of application: electrical work

y = 0.0019 × 10,000 ＋ 78.1407

= 97 ($\times 10^6$ yen)

Total cost of pumping station = 175+60＋97

= <u>332</u> ($\times 10^6$ yen)

(b) Pipeline

(DCIP φ400 mm、L = 4,100 m)

x： extension x = 4,100 m

y： construction cost ($\times 10^4$ yen)

- scope of application: no pavement, daytime construction

y = 6.1 × 4,100

= 25,010 ($\times 10^4$ yen)

= <u>250</u> ($\times 10^6$ yen)

Estimation

(a) + (b)

= 332 + 250

= <u>582</u> ($\times 10^6$ yen)

= 5,820,000 (US$)

2) Running Cost

<u>Pump</u>	motor	11	kw
	number of pump	2	Nos
	operating time	12	hr/day

<u>Contracti</u> 28 kw

Power = 11 kw × 2 × 1.25

= 27.5 (kw)

Basic Rate	in Tokyo	1,101.6	(yen/kw)
	discount	5	(%)

Basic Rate = 28 kw × 1,101.6 yen/kw × 0.95
= 29,302 (yen/month)

Utility Rate	in Tokyo	15.42	(yen/kw･H)

Utility Rate = 27.5 kw × 12 hr/day × 15.42 yen/kw･H × 30 days
= 152658 (yen/month)

Power Rate Basic Rate ＋ Utility Rate
= 29,302 ＋ 152658
= 181,960 (yen/month)
= 2.2 (10^6yen/year)

Running Cost 2.2 ＋ 0.1 = 2.3 (10^6yen/year)

3) LCC

(a) Pumping Station

Civil	175	(×10^6 yen)	durability: 50years
Machine and Electric	157	(×10^6 yen)	durability: 18years
Running cost	2.3	(×10^6 yen /year)	2.2＋0.1

(b) Pipeline

DCIP	250	(×10^6 yen)	durability: 40years

LCC： 175×1＋157×3＋2.3×50＋250×2
= 1,261 (×10^6 yen /50years)

(5) IV) from Ban Bwe Gon Reservoir

1) Initial Cost

(a) Pumping Station

(φ150mm × 22.0 kw × 1 Nos)

Punping Station (outside)

x： discharge x＝ 2,900 m^3/day

y： construction cost ($\times 10^6$ yen)

- scope of application: civil work (construction cost per depth)

y＝ 0.0056 × 2,900 ＋ 119.1249

＝ 135 ($\times 10^6$ yen)

- scope of application: machinery work

y＝ 0.0034 × 2,900 ＋ 25.8517

＝ 36 ($\times 10^6$ yen)

- scope of application: electrical work

y＝ 0.0019 × 2,900 ＋ 78.1407

＝ 84 ($\times 10^6$ yen)

Total cost of pumping station ＝ 135+36＋84

＝ 255 ($\times 10^6$ yen)

(b) Pipeline

(PVC φ200 mm、L＝ 4,300 m)

x： extension x＝ 4,300 m

y： construction cost ($\times 10^4$ yen)

- scope of application: no pavement, daytime construction

y＝ 2.8 × 4,300

＝ 12,040 ($\times 10^4$ yen)

＝ 120 ($\times 10^6$ yen)

Estimation

(a) + (b)

= 255 + 120

= 375 ($\times 10^6$ yen)

= 3,750,000 (US$)

2) Running Cost

Pump	motor	22	kw
	number of pump	1	Nos
	operating time	12	hr/day

Contracti 28 kw

Power = 22 kw × 1 × 1.25
= 27.5 (kw)

Basic Rate	in Tokyo	1,101.6	(yen/kw)
	discount	5	(%)

Basic Rate = 28 kw × 1,101.6 yen/kw × 0.95
= 29,302 (yen/month)

Utility Rate in Tokyo 15.42 (yen/kw･H)

Utility Rate = 27.5 kw × 12 hr/day × 15.42 yen/kw･H × 30 days
= 152658 (yen/month)

Power Rate Basic Rate ＋ Utility Rate
= 29,302 ＋ 152658
= 181,960 (yen/month)
= 2.2 (10^6yen/year)

Running Cost 2.2 ＋ 0.1 = 2.3 (10^6yen/year)

3) LCC

(a) Pumping Station

Civil	135	($\times10^6$ yen)	durability: 50years
Machine and Electric	120	($\times10^6$ yen)	durability: 18years
Running cost	2.3	($\times10^6$ yen /year)	2.2＋0.1

(b) Pipeline

PVC 120 ($\times 10^6$ yen) durability: 40years

LCC： 135×1＋120×3＋2.3×50＋120×2

＝ 850 ($\times 10^6$ yen /50years)

(6) V) New Reservoir Construction in the Thilawa SEZ area

1) Initial Cost

Sectional Area of the dam body：(3.0+3.0+3.6×(3+2))×3.6÷2+(3+1)×1÷2=45.2 m^2

Volume of the dam body：45.2 m^2×(600×4×2 places) = 216,960 m^3

216,960 m^3×8,000 yen/m^3 = 1,736 (10^6yen)

2) Running Cost

not considered for a repair of the dam body

3) LCC

LCC: 1,736 (10^6yen)

(7) VIa) from Khayan River

1) Initial Cost

(a) Pumping Station

(φ150mm × 37.0 kw × 1 Nos)

(φ150mm × 45.0 kw × 1 Nos)

Punping Station (outside)

x： discharge x＝ 4,000 m^3/day

y： construction cost ($\times 10^6$ yen)

- scope of application: civil work (construction cost per depth)

$y = 0.0056 \times 4{,}000 + 119.1249$

$= 142 \quad (\times 10^6 \text{ yen})$

- scope of application: machinery work

$y = 0.0034 \times 4{,}000 + 25.8517$

$= 39 \quad (\times 10^6 \text{ yen})$

- scope of application: electrical work

$y = 0.0019 \times 4{,}000 + 78.1407$

$= 86 \quad (\times 10^6 \text{ yen})$

Total cost of pumping station $= (142+39+86) \times 2$

$= \underline{534} \quad (\times 10^6 \text{ yen})$

(b) Pipeline Section 1

(PVC φ250 mm、L＝ 13,300 m)

x： extension x＝ 13,300 m

y： construction cost ($\times 10^4$ yen)

- scope of application: no pavement, daytime construction

$y = 2.9 \times 13{,}300$

$= 38{,}570 \quad (\times 10^4 \text{ yen})$

$= \underline{386} \quad (\times 10^6 \text{ yen})$

Pipeline Section 2

(PVC φ250 mm、L＝ 11,300 m)

x： extension x＝ 11,300 m

y： construction cost ($\times 10^4$ yen)

- scope of application: no pavement, daytime construction

$y = 2.9 \times 11{,}300$

$= 32{,}770 \quad (\times 10^4 \text{ yen})$

$= \underline{328} \quad (\times 10^6 \text{ yen})$

Total cost of pipeline = 386+328
= 714 ($\times 10^6$ yen)

(c) Storage Tank (RC)

x : capacity x = 1,400 m^3/day
y : construction cost ($\times 10^6$ yen)

- scope of application: RC

y = 0.11 × 1,400 + 0.2386
= 154 ($\times 10^6$ yen)

(d) Intake (RC)
convert from amount of intake water as 5% of water loss

x : capacity x = 4,000 m^3/day
y : construction cost ($\times 10^6$ yen)

- scope of application: RC

y = 0.0014 × 4,000 + 61.9784
= 68 ($\times 10^6$ yen)

Estimation
(a) + (b) + (c) + (d)
= 534 + 714 + 154 + 68
= 1,470 ($\times 10^6$ yen)
= 14,700,000 (US$)

2) Running Cost

pumping station 1

Pump	motor	37	kw
	number of pump	1	Nos
	operating time	12	hr/day

Contracti 47 kw

Power = 37 kw × 1 × 1.25
= 46.25 (kw)

<u>Basic Rate</u> in Tokyo 280.8 (yen/kwh)

Basic Rate = 47 kw × 280.8 yen/kw
= 13,197 (yen/month)

<u>Utility Rate</u> in Tokyo

19.43	円/kw・H	（- 120kwh）
25.91	円/kw・H	（120kwh - 300kwh）
29.93	円/kw・H	（300kwh -）

Power consumption = 46.25 kw × 12 hr/day × 30 days
= 16,650 (kwh)

Utility Charge 1 = 120 kwh × 19.43 yen/kw・H
= 2,332 (yen/month)

Utility Charge 2 = 180 kwh × 25.91 yen/kw・H
= 4,664 (yen/month)

Utility Charge 3 = 16,350 kwh × 29.93 yen/kw・H
= 489,356 (yen/month)

Total = 496,351 yen/month

<u>Power Rate</u> Basic Rate ＋ Utility Rate
= 13,197 ＋ 496,351
= 509,548 (yen/month)
= 6.1 (10^6yen/year)

<u>Running Cost</u> 6.1 ＋ 0.1 = 6.2 (10^6yen/year)

pumping station 2

<u>Pump</u> motor 37 kw
number of pump 1 Nos

operating time 12 hr/day

<u>Contracti</u> 47 kw

Power = 37 kw × 1 × 1.25
= 46.25 (kw)

<u>Basic Rate</u> in Tokyo 280.8 (yen/kwh)

Basic Rate = 47 kw × 280.8 yen/kw
= 13,197 (yen/month)

<u>Utility Rate</u> in Tokyo
19.43 円/kw・H （- 120kwh）
25.91 円/kw・H （120kwh - 300kwh）
29.93 円/kw・H （300kwh -）

Power consumption = 46.25 kw × 12 hr/day × 30 days
= 16,650 (kwh)

Utility Charge 1 = 120 kwh × 19.43 yen/kw・H
= 2,332 (yen/month)

Utility Charge 2 = 180 kwh × 25.91 yen/kw・H
= 4,664 (yen/month)

Utility Charge 3 = 16,350 kwh × 29.93 yen/kw・H
= 489,356 (yen/month)

Total = 496,351 yen/month

<u>Power Rate</u> Basic Rate ＋ Utility Rate
= 13,197 ＋ 496,351
= 509,548 (yen/month)
= 6.1 (10^6yen/year)

<u>Running Cost</u> 6.1 ＋ 0.1 = 6.2 (10^6yen/year)

3) LCC

(a) Pumping Station

Civil	142	($\times 10^6$ yen)	durability: 50years
Machine and Electric	125	($\times 10^6$ yen)	durability: 18years
Running cost	12.4	($\times 10^6$ yen /year)	6.2＋6.2

(b) Pipeline

PVC	714	($\times 10^6$ yen)	durability: 40years

(c) Storage Tank

Civil	154	($\times 10^6$ yen)	durability: 50years

(d) Intake

Civil	68	($\times 10^6$ yen)	durability: 50years

LCC： 142×1＋125×3＋12.4×50＋714×2＋154×1＋68×1

＝ 2,787 ($\times 10^6$ yen /50years)

6-3 Mid-Term Plan

The required capacity of the water supply for the Mid-Term Plan of Thilawa SEZ is proposed as a volume of 42,000 m^3/day with the main water resources being La Gun Byin Reservoir and Aline Nee Reservoir. The main supply works from the two resources to Thilawa SEZ is designed as a pipe line, pump stations and water purifying plants by the JICA Study Team with the total pipe line route to be approximate 80 km, including the cross of the Bago River at nearly 1 km in length. The location map of Mid-Term Plan is shown in Figure 6-3-1.

Figure 6-3-1 Location Map of Mid-Term Plan

6-3-1 Main Water Resources

There are two reservoirs providing the water resources for Thilawa SEZ, one being the La Gun Byin Reservoir, which is located at 80 km north of Thilawa SEZ and was constructed at 2001 by the Irrigation Department and the other being the Aline Nee Reservoir, which is adjacent to the La Gun Byin Reservoir and was constructed at 2002 by the Irrigation Department as well.

The height of the La Gun Byin Reservoir is 18.9 m and the crest length is 1,578.8 m. The dam is a earth dam and a homogeneous type. The catchment area is 108.7 km^2 and the dam has the storage capacity of 183.6 MCM (Mega Cube Meters). The La Gun Byin Reservoir is initially for the irrigation water and has about 8,900 ha of the irrigation area but the plan of the irrigation area at

2002 is only 3,562.2 ha. The La Gun Byin Reservoir has the excess water too much.

The Aline Nee Reservoir adjoins the La Gun Byin Reservoir and the height of the Aline Nee Reservoir is 15.8 m and the crest length is 1737.4 m. The dam body is the earth dam of a homogeneous type. The catchment area is 36.8 km^2 and the dam has a storage capacity of 48.1 MCM.

Table 6-3-1 Specifications of La Gun Byin and Aline Nee Reservoirs

No.	Subject	La Gun Pyin				Ah Lai Ni			
1	Location	Border of Yangon Division and Bago Division, Near Tha me ka lay Village				Bago Township, Inn sa laung Village,near Kyan khun Village			
2	Map Reference	94 C/7 L 718932				94 C/7 L 748938			
3	Name of Chaung	La gun pyin chaung				La gun pyin chaung			
4	Catchment area	42	Square-mile	108.7	km^2	14	Square-mile	36.8	km^2
5	Average annual rain fall	100	inch	2540	mm	100	inch	2540	mm
6	Average Annual Inflow	126,000	Ac-ft	155.5	MCM	42,600	Ac-ft	52.6	MCM
7	Type of Dam	Earth Dam				Earth Dam			
8	Height of Dam	62	ft	18.9	m	52	ft	15.8	m
9	Length of Dam	5,180	ft	1578.9	m	5,700	ft	1737.4	m
10	Storage Capacity of Full Tank	148,800	Ac-ft	183.6	MCM	39,000	Ac-ft	48.1	MCM
11	Dead Storage Capacity	5,250	Ac-ft	6.5	MCM	1,780	Ac-ft	2.2	MCM
12	Water Spread Area of F.T.L	6,700	Acre	27.1	km^2	2,060	Acre	8.3	km^2
13	Type of Conduit	Reinforce Cement Concrete				Reinforce Cement Concrete			
14	Size of Conduit	4 ft x 6 ft, 2rows	ft	1.2 x1.8, 2rows	m	4 ft x 6 ft, 1row	ft	1.2x1.8, 1row	m
15	Length of Conduit	244	ft	74.4	m	240	ft	73.2	m
16	Conduit Design Discharge	500	Cuft/sec	14.2	m^3/sec	150	Cuft/sec	4.2	m^3/sec
17	Type of Spillway	Reinforce Cement Concrete(Broad Crest)				No Spillway			
18	Width of Spillway	50	ft	15.2	m	-	ft	-	m
19	Spillway Design Discharge	900	Cuft/sec	25.5	m^3/sec	-	Cuft/sec	-	m^3/sec
20	Irrigable Area (Acre)	22,000	Acre	8905.6	ha	Including La Gun Pyin Area			
	Yangon Division, Hle gu Township	12,000	Acre	4857.6	ha				
	Bago Division, Bago Township	10,000	Acre	4048.0	ha				
	*Plan of Irrigation Area at 2002	8,800	Acre	3562.2	ha				
	*As of 2012	4,000	Acre	1619.2	ha				

Figure 6-3-2 Location of La Gun Byin and Aline Nee Reservoirs

6-3-2 Issues of Main Reservoirs

(1) La Gun Byin Reservoir

The La Gun Byin Reservoir has a spillway of a broad crest type that is 15.2 m (=50 feet) in width. The design discharge of the spillway is 25.5 m^3/sec.

The freeboard of the dam crest for High Water Level at flood flow is only 1 m (=3.3 feet).

(2) Aline Nee Reservoir

The Aline Nee Reservoir has no spillway and connects with the La Gun Byin Reservoir through the connecting canal, which is 200 m in width and 1 km in length.

The catchment area both the La Gun Byin (108.7 km^2) and the Aline Nee (36.8 km^2) is 145.5 km^2 and the total storage capacity is 231.7 MCM (La Gun Byin: 183.6 MCM, Aline Nee: 48.1 MCM). The total water spread area at F.W.L. (Full Water Level) is 35.4 km^2 (La Gun Byin: 27.1 km^2, Aline Nee: 8.3 km^2).

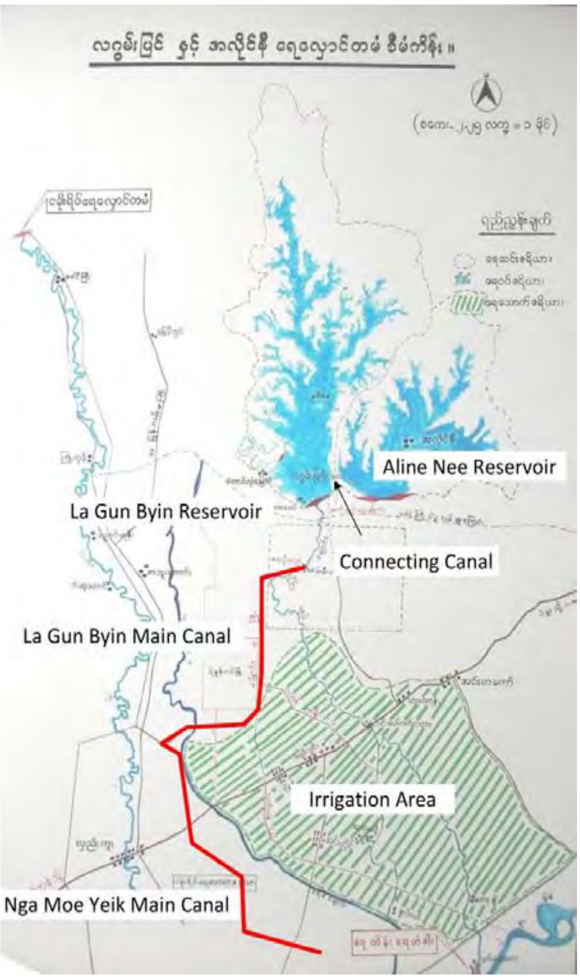


Figure 6-3-3 Map of La Gun Byin and Aline Nee Reservoirs

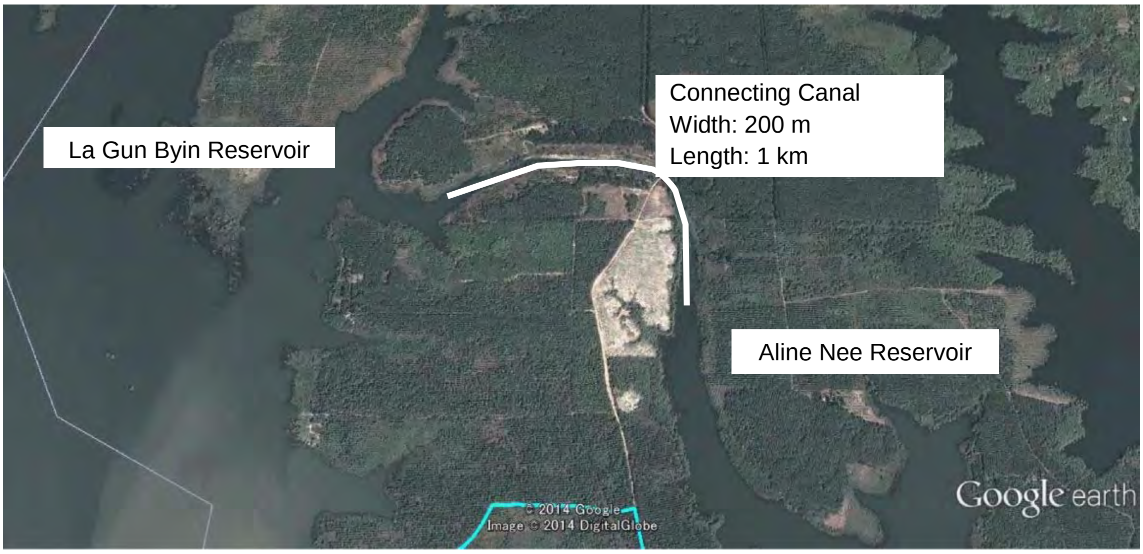


Figure 6-3-4 Location of Connecting Canal

Figure 6-3-5 La Gun Byin Reservoir

Figure 6-3-6 Intake Tower at La Gun Byin

Figure 6-3-7 Spillway Crest at La Gun Byin

Figure 6-3-8 Spillway Bridge at La Gun Byin

Figure 6-3-9 Water Level Recorder

Figure 6-3-10 Outlet Work at La Gun Byin

Figure 6-3-11 Aline Nee Reservoir

Figure 6-3-12 Intake Tower at Aline Nee

6-3-3 Spillway of La Gun Byin Reservoir

(1) Flood Discharge

The data of the estimated river discharges at the point of the La Gun Byin Reservoir for 30 years (1984 ~ 2013) are as follows:

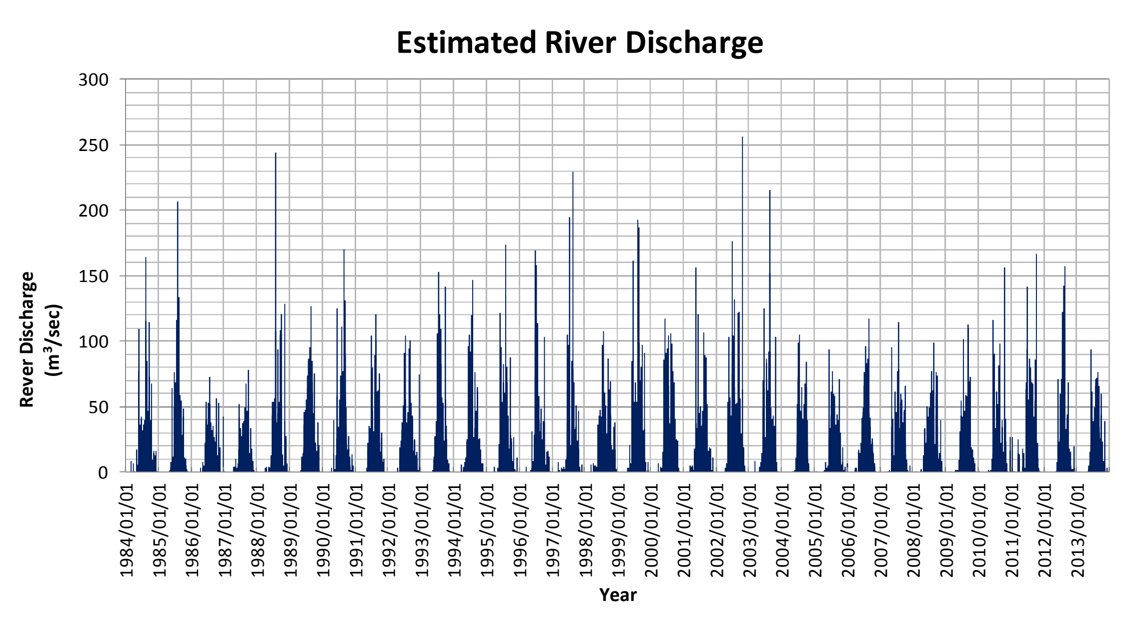


Figure 6-3-13 Estimated River Discharges at La Gun Byin

The catchment area both the La Gun Byin (108.7 km^2) and the Aline Nee (36.8 km^2) is 145.5 km^2 and the maximum river discharge for 30 years is 255.7 m^3/sec at 21st October 2002.

The construction of the La Gun Byin Reservoir accomplished at 2001 and the Aline Nee Reservoir completed at 2003. After the completion of the dam works, the maximum river discharges of each year are 90 m^3/sec ~ 150 m^3/sec.

As the design discharge of the spillway at the La Gun Byin Reservoir is 25.5 m^3/sec and the Aline Nee Reservoir has no spillway, the flood water will overflow the dam crest every year and it will be very dangerous for the dam safety.

Table 6-3-2 Maximum River Discharges for each 30 years

No.	Date	River Discharge (m^3/sec)	Remark
1	09 August 1984	163.9	
2	29 July 1985	206.2	
3	20 July 1986	72.5	
4	23 September 1987	78.4	
5	22 July 1988	244.1	
6	17 August 1989	126.4	
7	25 August 1990	170.5	
8	21 August 1991	120.4	
9	07 July 1992	103.8	
10	06 July 1993	152.9	
11	24 July 1994	146.2	
12	03 August 1995	173.9	
13	30 June 1996	169.1	
14	18 August 1997	229.2	
15	25 July 1998	107.4	
16	07 August 1999	192.4	
17	12 June 2000	117.3	
18	18 May 2001	156.6	Complettion of Lagunbyin
19	21 October 2002	255.7	Maximum Discharge
20	14 August 2003	215.6	Completion of Alaini
21	12 July 2004	105.3	
22	09 June 2005	93.6	
23	22 August 2006	117.3	
24	21 July 2007	114.2	
25	13 August 2008	98.9	
26	02 September 2009	112.9	
27	17 October 2010	156.2	
28	29 September 2011	166.3	
29	10 August 2012	157.3	
30	09 June 2013	93.6	

(2) Flood Flow Analysis

The design flood discharge should be determined on the basis of hydrometeorology surveys and analyses. The design flood level is defined as the maximum reservoir water level when the design flood discharge occurs.

The design flood discharge is the flood discharge designated for the purpose of securing the safety of the dam and is obtained by adding 20 percent to the maximum values among the followings:

(A) 200-years flood, which statistically occurs once in 200 years, namely the return period discharge of a flood that could occur every 200 years (herein after referred to as "discharge A")

(B) Maximum experienced flood discharge estimated on the basis of flood records or flood mark survey (herein after referred to as "discharge B")

(C) Maximum flood discharge estimated from hydrological or meteorological records obtained from a nearby watershed with hydro-meteorological characteristics similar to those of the subject river (hereinafter referred to as "discharge C")

The design flood discharge is the maximum flood discharge to be considered for dam design. Therefore the maximum flood, from an engineering view point, expected to occur at the given dam site shall be adopted as the design flood discharge.

(3) 200 Years Flood

There are two methods to estimate the flood discharge which statistically occurs once in 200 years. One is to estimate directly from the frequently analysis of long term records on flood discharge. The other is to estimate indirectly based on the long term records on rainfall and characteristics of flood discharge in the given watershed.

(4) Iwai Method

The Iwai method is one of probability of exceedance calculations and return periods are obtained. The statistics method is often used at the probability of the exceedance issues in Japan.

Probability of exceedance $W(x) = \frac{1}{2} \cdot (1 - F(\xi))$

Asymmetrical distribution $f(x) = \exp(-(\alpha \cdot \log \frac{x-b}{x_0 - b})^2)$

Exceedance probability function

$$F(\xi) = \frac{2}{\sqrt{\pi}} \cdot \int_0^{\xi} \exp(-t^2)$$

$$\xi = \alpha \cdot \log \frac{x-b}{x_0 - b}$$

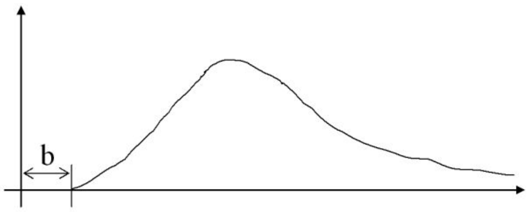


Table 6-3-3 Descending Order of Maximum River Discharges

No.	Date	River Discharge (m^3/sec)	Remark
1	21 October 2002	255.7	
2	22 July 1988	244.1	
3	18 August 1997	229.2	
4	14 August 2003	215.6	
5	29 July 1985	206.2	
6	07 August 1999	192.4	
7	03 August 1995	173.9	
8	25 August 1990	170.5	
9	30 June 1996	169.1	
10	29 September 2011	166.3	
11	09 August 1984	163.9	
12	10 August 2012	157.3	
13	18 May 2001	156.6	
14	17 October 2010	156.2	
15	06 July 1993	152.9	
16	24 July 1994	146.2	
17	17 August 1989	126.4	
18	21 August 1991	120.4	
19	12 June 2000	117.3	
20	22 August 2006	117.3	
21	21 July 2007	114.2	
22	02 September 2009	112.9	
23	25 July 1998	107.4	
24	12 July 2004	105.3	
25	07 July 1992	103.8	
26	13 August 2008	98.9	
27	09 June 2005	93.6	
28	09 June 2013	93.6	
29	23 September 1987	78.4	
30	20 July 1986	72.5	

The results of the Iwai method are shown at Table 3-4

Table 6-3-4 Results of Iwai Method

Return Period T year	ξ	1/a･ξ	Average: Y+1/a･ξ	x+b	Return Period Probability (m^3/sec) x
2	0	0	2.126340573	133.7644	140
5	0.5951	0.126985	2.25332594	179.195	185
10	0.9062	0.193369	2.319709989	208.7901	215
20	1.163	0.248167	2.374507237	236.8685	243
30	1.2967	0.276696	2.403036802	252.9512	259
50	1.452	0.309835	2.43617548	273.0081	279
100	1.645	0.351018	2.47735877	300.1641	306
200	1.8215	0.388681	2.515021209	327.3567	333
500	2.035	0.434238	2.56057889	363.5623	370
1000	2.185	0.466246	2.592586628	391.3692	397

According to the results of the Iwai method, the return period discharge of a flood that could occur every 200 years is calculated at 333 m^3/sec and the design spillway discharge is 400 m^3/sec (≒ 333 m^3/sec×1.2). The discharge is larger than the design discharge of the La Gun Byin Reservoir which is 25.5 m^3/sec.

(5) Spillway at La Gun Byin Reservoir

The spillway of the La Gun Byin Reservoir is located at the left abutment of the dam. The width of the spillway is 50 feet (= 15.25 m) and the design discharge is 25.5 m^3/sec. The largest recorded flood level was 86.7 feet (= 26.43 m) and it was High Water Level on 21st August 2012. F.W.L. (Full Water Level) of the La Gun Byin Reservoir is 82 feet (= 25.0 m).

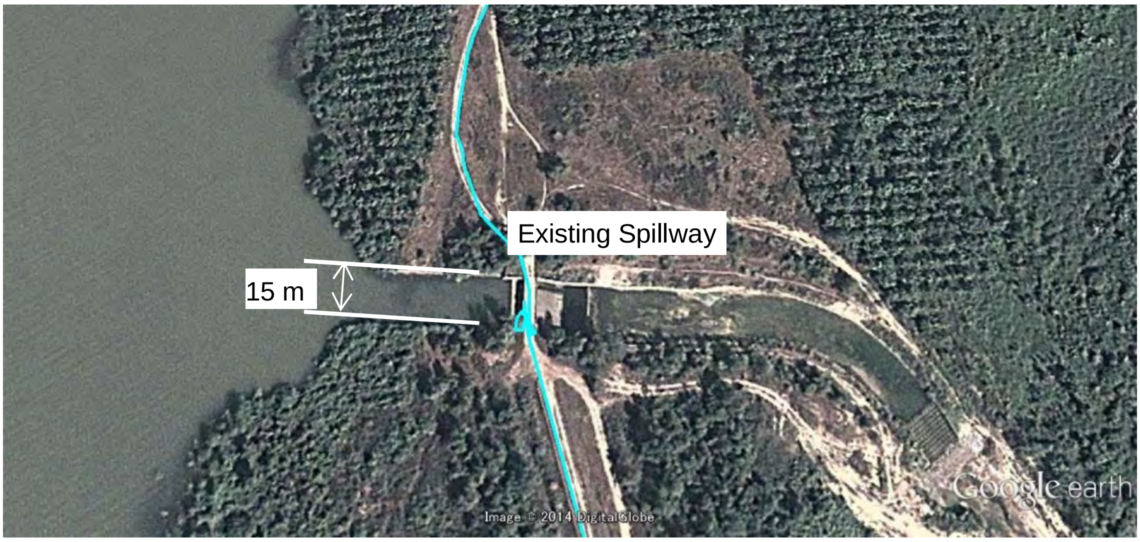


Figure 6-3-14 Location of Spillway at La Gun Byin Reservoir

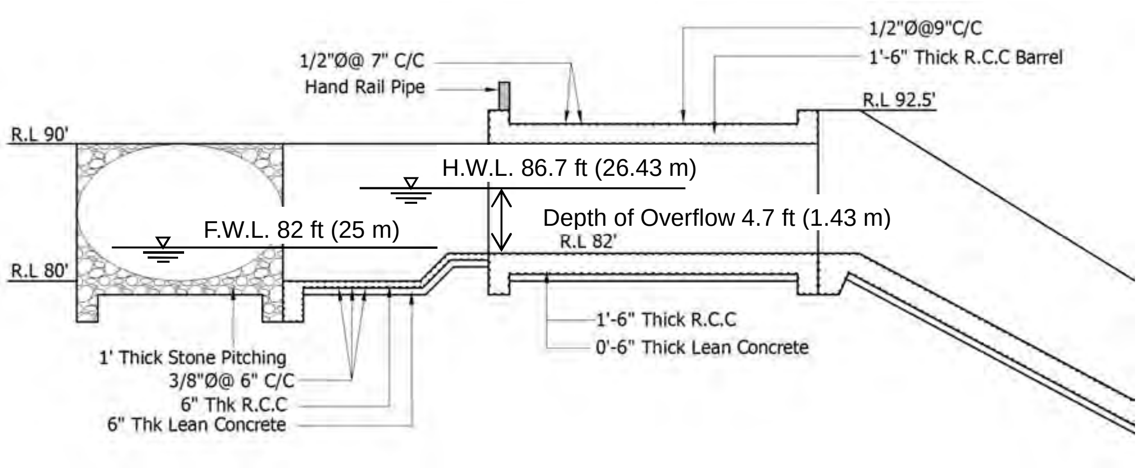


Figure 6-3-15 Longitudinal Section of Spillway

(6) Flood Discharge at Largest Recorded Flood

The Flood Discharge during the largest recorded flood is estimated by the calculation of the following equation:

$Q = C \cdot L \cdot H^{(3/2)}$

where Q: Discharge (m^3/sec)

C: Coefficient of flow = 1.8

L: Width of spillway = 50 ft = 15.25 m

H: Depth of overflow = H.W.L. 86.7ft - F/W.L. 82.0ft = 4.7 ft ≒ 1.5 m

$Q = 1.8 \times 15.25 \times 1.5^{(3/2)} \fallingdotseq 50\ m^3/sec > 25.5\ m^3/sec$

The flood discharge during the largest recorded flood (=50 m^3/sec) is larger than the design discharge of the spillway (=25.5 m^3/sec) and is smaller than the return period discharge of a flood that could occur every 200 years (333 m^3/sec).

(7) Safety of Spillway

The width of the spillway at the La Gun Byin Reservoir is too narrow to flow the return period discharge of a flood that could occur every 200 years and it is necessary to enlarge the width of the weir up to 100 m in width for safety reasons in case of floods coming every 200 years.

$Q = C \cdot L \cdot H^{(3/2)}$

where Q: Discharge (= 333 m^3/sec: 200 years flood)

C: Coefficient of flow = 1.8

L: Width of spillway

H: Depth of overflow = H.W.L. 86.7ft - F/W.L. 82.0ft = 4.7 ft≒1.5 m

$L = 333/(1.8 \times 1.5^{(3/2)}) \fallingdotseq 100m$

If the return period discharge of a flood that could occur every 200 years is coming for the existing spillway which is the crest weir of 15 m in width, how much is the depth of the overflow at the weir?

$Q = C \cdot L \cdot H^{(3/2)}$

where Q: Discharge (= 333 m^3/sec: 200-years flood)

C: Coefficient of flow = 1.8

L: Width of spillway = 50 ft = 15.25 m

H: Depth of overflow

$H = (333/(1.8 \times 15.25))^{(2/3)} \fallingdotseq 5.3$ m

Flood water level = F.W.L. 25.0 m + 5.3 m = 30.3 m

Flood water level - Dam crest level = 30.3 m - 27.5 m = 2.8 m

The return period discharge of a flood that could occur every 200 years will be able to overflow the dam crest more than 2.8 m in height.

6-3-4 Freeboard of La Gun Byin Reservoir

(1) Water Level of Reservoir

The existing water levels of the La Gun Byin reservoir are as follows:

Table 6-3-5 Specifications of Reservoir

Subject	La Gun Byin Reservoir	
Catchment area	108.7	km^2
Average annual rain fall	2540	mm
Average Annual Inflow	155.5	MCM
Type of Dam	Earth Dam	
Height of Dam	18.9	m
Length of Dam	1578.9	m
Storage Capacity of Full Tank	183.6	MCM
Dead Storage Capacity	6.5	MCM
Water Spread Area of F.T.L	27.1	km^2

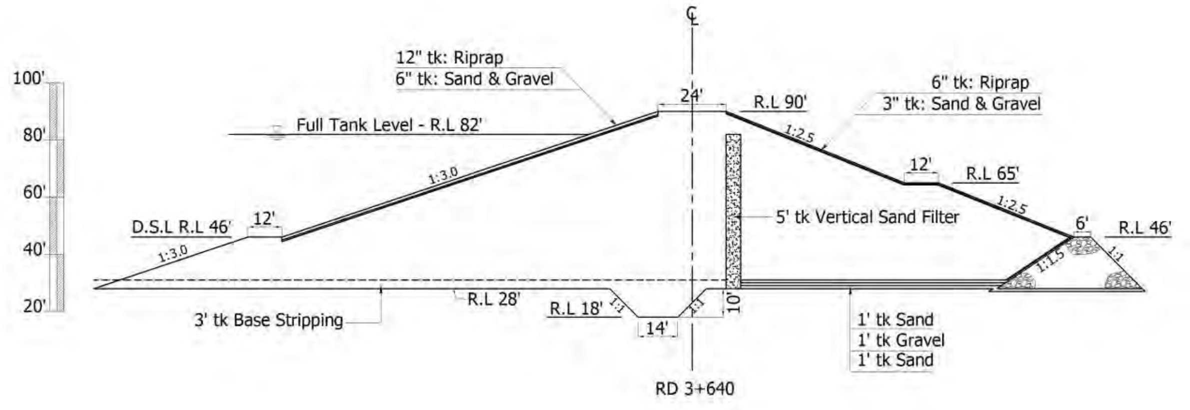


Figure 6-3-16 Typical Cross Section of La Gun Byin Reservoir

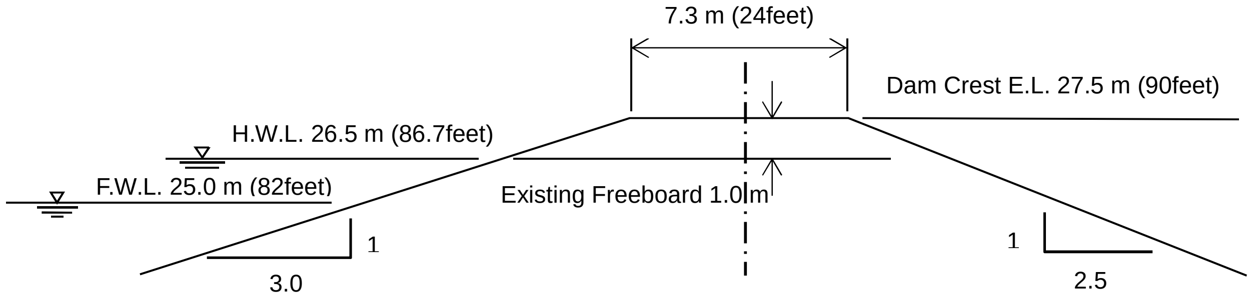


Figure 6-3-17 Detail of Dam Crest

The elevation of the existing dam crest is EL. 27.5 m (90ft) and H.W.L. 26.5 m (86.7 ft). The freeboard of the existing dam crest is as follows:

Dam crest level - H.W. L = 27.5 m - 26.5 m = 1.0 m

(2) Dam Crest Level

The calculation of the dam crest level shall follow the "Engineering Manual for Irrigation and Drainage by the Japanese Institute of Irrigation and Drainage". The La Gun Byin Reservoir applies to the case of the spillway without gate and the overflow depth which is less than 2.5 m. The elevation of non-overflow section or the dam crest is decided as the value which is more than the maximum height showed in the Table 6-3-6.

(3) Wave Height from Reservoir Surface

Wave height from reservoir surface by wind shall be determined considering the relationship between the wind velocity and the fetch on design flood level, and also consideration to wave reflection and wave run-up height depending on the structural form of the dam body.

1) Fetch

Fetch is the free surface distance to wave by wind. Fundamentally it will be a distance in a straight line in the direction of maximum wind velocity.

F: fetch in km (= 8 km)

2) Wind Velocity

If no data is available on wind velocity according to long-term observation at site, it shall be in principle 30 m/sec, however, 20 m/sec may be acceptable for a dam site where there is no danger of strong wind.

V: wind velocity 30 m/sec

Table 6-3-6 Elevations of Non-Overflow Section

Dam Type	Concrete Dam	Fill Dam	
Overflow Depth Hd / Spillway Gate	—	Hd>2.5 m	Hd≦2.5 m
Dam with Spillway Gate	Hf+hw+he+0.5 (If "hw+he <1.5" is Hf+2) Hs+hw+he/2+0.5 (If "hw+he/2 <1.5" is Hs+2) Hh+hw+0.5 (If "hw <1.5" is Hh+2)	Hf+hw+he+1.5 (If "hw+he<1.5" is Hf+3) Hs+hw+he/2+1.5 (If "hw+he/2<1.5" is Hs+3) Hh+hw+1.5 (If "hw<0.5" is Hh+2)	Hf+hw+he+1.5 (If "hw+he<1.5" is Hf+3) Hs+hw+he/2+1.5 (If "hw+he/2<1.5" is Hs+3) Hh+hw+1.5 (If "hw<0.5" is Hh+2)
Dam without Spillway Gate	Hf+hw+he (If "hw+he<2" is Hf+2) Hs+hw+he/2 (If "hw+he/2<2" is Hs+2) Hh+hw (If "hw<1" is Hh+1)	Hf+hw+he+1 (If "hw+he<2" is Hf+3) Hs+hw+he/2+1 (If "hw+he/2<2" is Hs+3) Hh+hw+1 (If "hw<1" is Hh+2)	Hf+hw+he+1 (If "hw+he<1" is Hf+2) Hs+hw+he/2+1 (If "hw+he/2<1" is Hs+2) Hh+hw+1 (If "hw<1" is Hh+2)

Note

Hf、hw、he，Hs and Hd indicate the following each values.

Hf: Full Water Level (Unit: m

Hs: Surcharge Water Level (Unit: m）

Hh: Design Flood Level (Unit: m)

Hw: Wind induced wave height from reservoir surface (Unit: m)

He: Earthquake induced wave height from reservoir surface by earthquake (Unit: m)

Hd: Overflow depth when design flood discharge overflow spillway (unit: m)

3) Roughness of Slope

Smooth surface slope is a relative even surface slope which is made of concrete block or stone pitch. The La Gun Byin Reservoir is riprap slope in order to absorb wave force between rock fragments.

4) Slope of Dam

In the case of riprap, wave run-up height is not affected by slope, but for the case of smooth surface slope, such depends on the steepness of slope and fetch. As a result, no consideration is required for riprap slope in determining wave run-up height, but for the low dam with smooth surface slope, the steeper the slope, the greater the wave run-up height.

Slope of dam (the upstream side): 1:3.0

Approximate value of wave run-up height R shall be found as shown in Figure 6-3-18 which shows the relationship between wave run-up height and other factors such as wave height and wave length obtained by S.M.B method, and upstream slope, and slope protection materials by the Saville method.

Freeboard for wind action would be decided by using Wave run-up height by Wilson's improved formula in S.M.B method and Saville method.

For the reasons mentioned above, the wave height from reservoir surface is decided as follows:

Wind height: 1.4 m

(4) Wave Height from Reservoir Surface by Earthquake

Freeboard for earthquake shall be calculated by using Seiichi Sato Formula as follows.

$$he = \frac{1}{2} \cdot \frac{K \cdot \tau}{\pi} \cdot \sqrt{g \cdot H_0}$$

Where,

he: wave height from reservoir surface by earthquake in meter

K: Design seismic coefficient (=0.15)

τ: Seismic period (s); one second for most case

H0: Depth of reservoir at full water level in meter (= 16.5 m)

g: Acceleration of gravity in meter per sq-second

Then,

$$he = \frac{1}{2} \times \frac{0.15 \times 1.0}{\pi} \times \sqrt{9.8 \times 16.5} = 0.3 \quad \text{(m)}$$

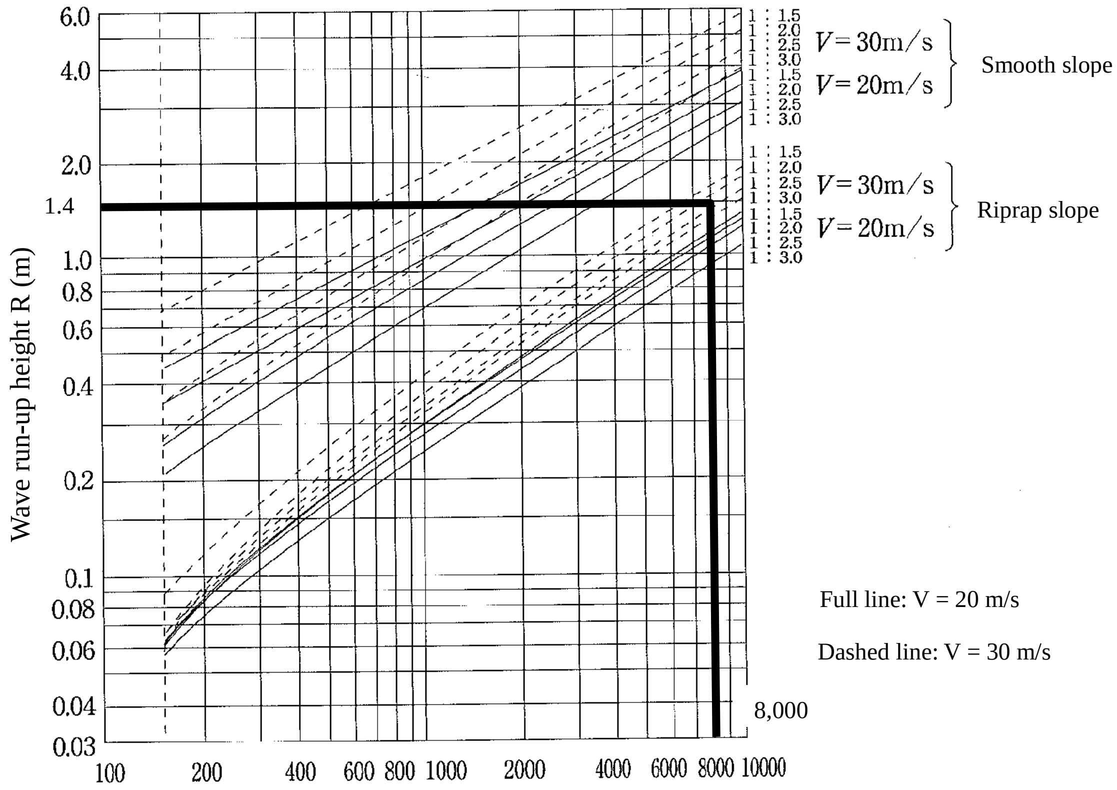


Figure 6-3-18 Wilson's Improved Formula in S.M.B and Saville Method

(5) Crest Level

The crest level shall be decided by using the "Engineering Manual for Irrigation and Drainage by the Japanese Institute of Irrigation and Drainage" standard in Japanese as follows.

CL1 = Hn + hw + he + 1 (unit: m)

CL2 = Hs + hw + he/2 + 1 (unit: m)

CL3 = Hd + hw +1 (unit: m)

Where CL1: Dam crest level based on full water level in meter

CL2: Dam crest level based on surcharge water level in meter

CL3: Dam crest level based on high water level in meter

Hf: Full water level in meter

Hs: Surcharge water level in meter

Hd: High water level in meter

Dam height------------------------23.5 m (77.1 feet)
Dam crest elevation--------------EL. 29.0 m (95.1 feet)
Full Water Level------------------F.W.L. 25.0 m (82 feet)
High Water Level-----------------H.W.L. 26.5 m (86.7 feet)

Table 6-3-7 Calculation of Dam Crest

(Fill dam with no gated spillway and overflow depth is less than 2.5 m)

Dam	Lagubyin Reservoir		
Spillway width	Service spillway	15.42 m	50 feet
Hn: Full Water Level		EL. 24.99 m	EL. 82 feet
Hs: Sercharge Level		-	-
Hd: High Water Level		EL. 26.50 m	EL. 86.9 feet
Over flow depth		1.50 m	4.9 feet
hw: wave height by wind	Slope: 1: 3.0 Riprap		
Wave height from reservoir surface shall be calculated by using Molitor-Stevenson Formula.	F: fetch in km	8.0	km
	V: wind velocity in km per hour	30.0	m/sec
	Wind velocity applies to the value of 30 m/sec, because there is no long term observation for wind velocity of 20 m/sec.		
	hw=	1.40 m	4.59 feet
he: wave height by earthquake	K: Design seismic coefficient	0.15	
	τ: seismic period (s),	1.00	
	H: Depth of reservoir at full water level (m)		
	Full water level F.W.L	EL. 24.99 m	EL. 82.00 feet
	Dam foundation level	EL. 8.54 m	EL. 28.02 feet
	Depth of reservoir	16.45 m	53.98 feet
	g: Acceleration of gravity	9.80	m/s2
	$he = 0.5 \times K \times \tau \times \pi \times (g \times H)^{0.5}$	0.30 m	0.09 feet
Hn:Full Water Level	Hn＋hw＋he + 1.0 = if hw＋he＜1.0, Hn＋2.0	EL.27.70 m	EL. 90.87 feet
Hs: Sercharge Level	Hs＋hw＋he/2 + 1.0＝ if hw＋he/2＜1.0, Hs＋2.0	-	-
Hd: High Water Level	Hd＋hw + 1.0＝ if hw < 1.0, Hd＋2.0	EL. 28.90 m	EL. 94.80 feet
Maximum elevation		EL. 28.90 m	EL. 94.80 feet
protection thickness		0.10 m	0.33 feet
Dam crest elevation		EL. 29.00 m	95.13 feet
Minimum elevation		EL. 5.49 m	EL. 18.00 feet
Dam height		23.51 m	77.13 feet
Design dam crest elevation		29.00 m	95.14 feet
Dam crest width		7.32 m	24.00 feet

Hn＋hw＋he + 1.0＝	EL.	27.70	hw＋he	
Hn＋2.0	EL.	26.99		1.70
Hs＋hw＋he/2 + 1.0＝	EL.	-	hw＋he/2	
Hs＋2.0	EL.	-		1.55
Hd＋hw + 1.0＝	EL.	28.90	hw	
Hd＋2.0	EL.	28.50		1.40

The calculated elevation of the dam crest is EL. 29.0 m (95.1 feet) and the design freeboard is as follows:

Design freeboard = Calculated dam crest - H.W. L. = 29.0 - 26.5 = 2.5 m

And

Calculated dam crest - Existing Dam crest = 29.0 - 27.5 = 1.5 m

It is necessary to raise the dam crest of 1.5 m for the improvement of the dam safety.

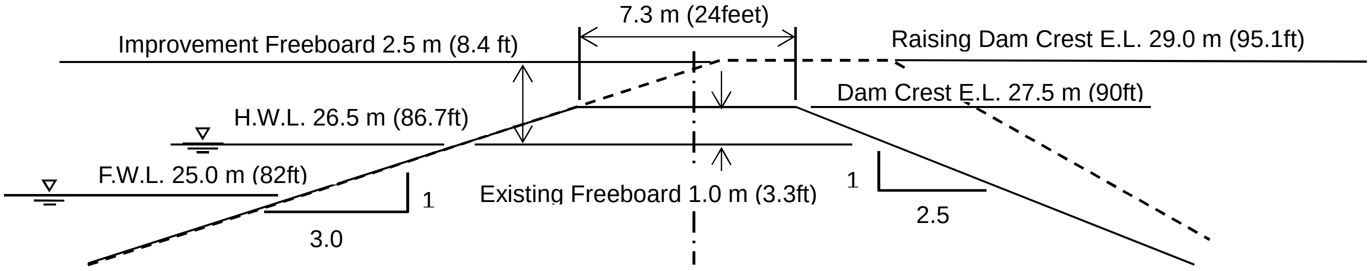


Figure 6-3-19 Raising Dam Crest

6-4 Long-Term Plan

The required capacity of water plan for the Long-Term Plan is proposed as a volume of 120,000 m^3/day (= 42,000 m^3/day + 78,000 m^3/day) with the main water resource being the Dawei Dam. The main supply route from the Dawei Dam to Thilawa SEZ is utilized with the existing rivers and canals, (Dawei River, Bago River, Zaungtu Weir, Zaungtu Canal, Bago-Sittung Canal, 30-miles Greening Canal, Khayan River and Khayan Sluice). The total supply route is approximately 200 km, and the Irrigation Department is making the design for the Dawei Dam.

The location map of Long-Term Plan is portrayed below.

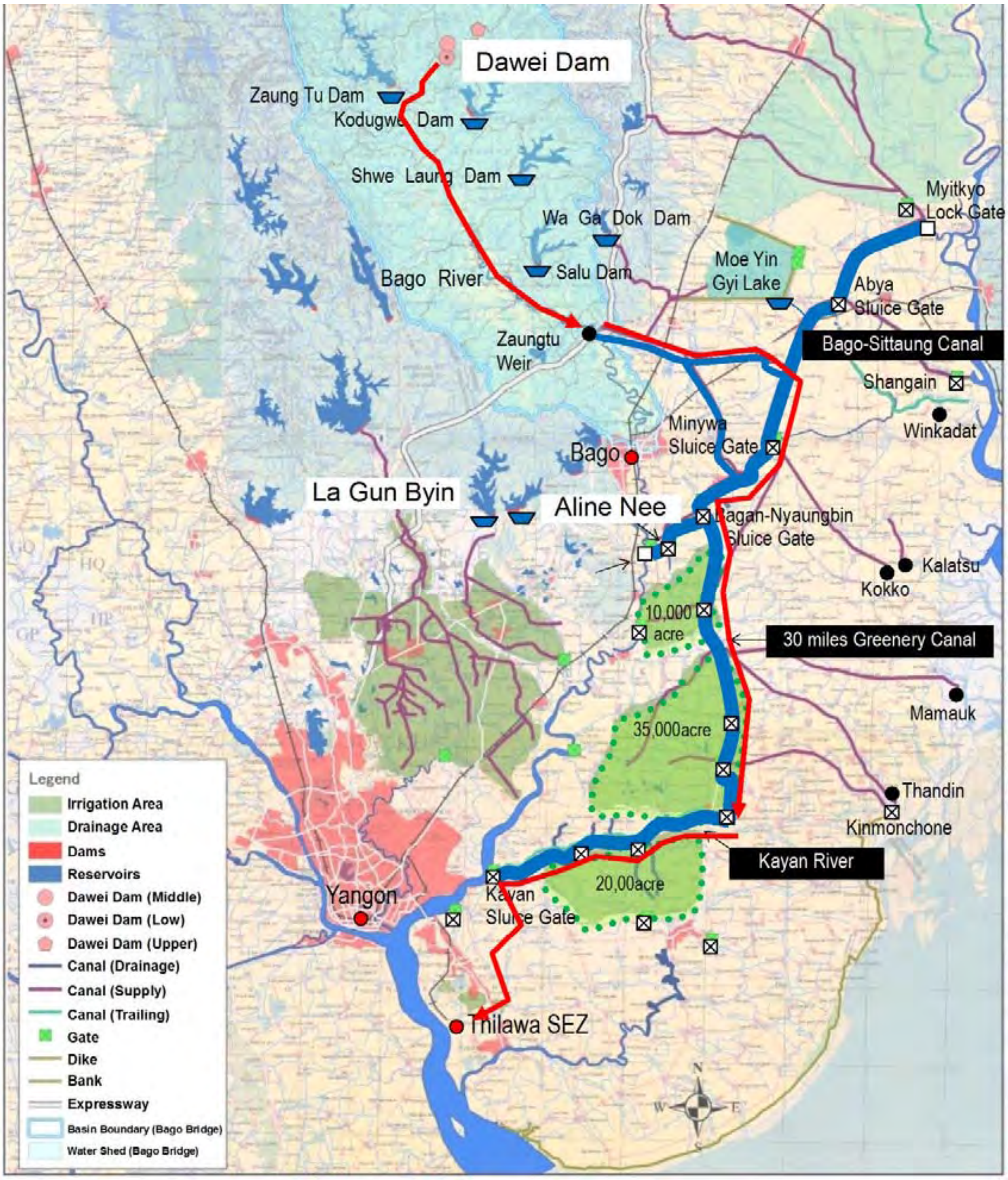


Figure 6-4-1 Location Map of Long-Term Plan

6-4-1 Sites of the Dawei Dam

The Dawei dam which is the water resource of the Long-Term Plan is designed by the Irrigation Department with three proposed sites at the upstream side of the Zaungtu dam. The location map of the proposed site is shown in Figure 6-4-2.

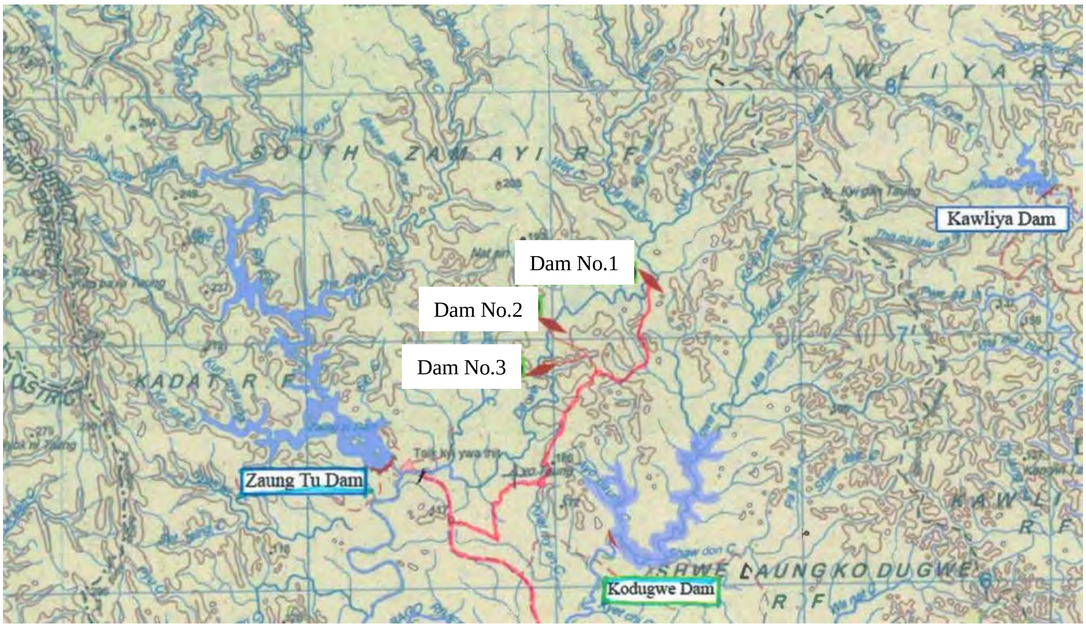


Figure 6-4-2 Location Map of Dam's Proposed Sites

The total capacity of the Dawei dam is estimated at 150 MCM with the height of the dam being designed as about 30 m. The downstream side of the dam site has the advantage of higher capacity as opposed to the upstream side because the catchment area of the downstream side is larger than that of the upstream side. At the proposed site of No.3, the height of the dam is designed as 30 m, and the No. 3 dam site saves 150 MCM (Mega Cube Meter) of water for the reservoir.

Table 6-4-1 Three Proposed Sites of Dawei Dam

No.	Candidate Site	Catchment Area (km^2)	Annual inflow (MCM m^3)	Site
1	Dam No.1	98.1	128.2*	Upstream
2	Dam No.2	120.6	161.1*	Middle
3	Dam No.3	125.1	200.0	Downstream

) The values of '' mark are calculated by ID

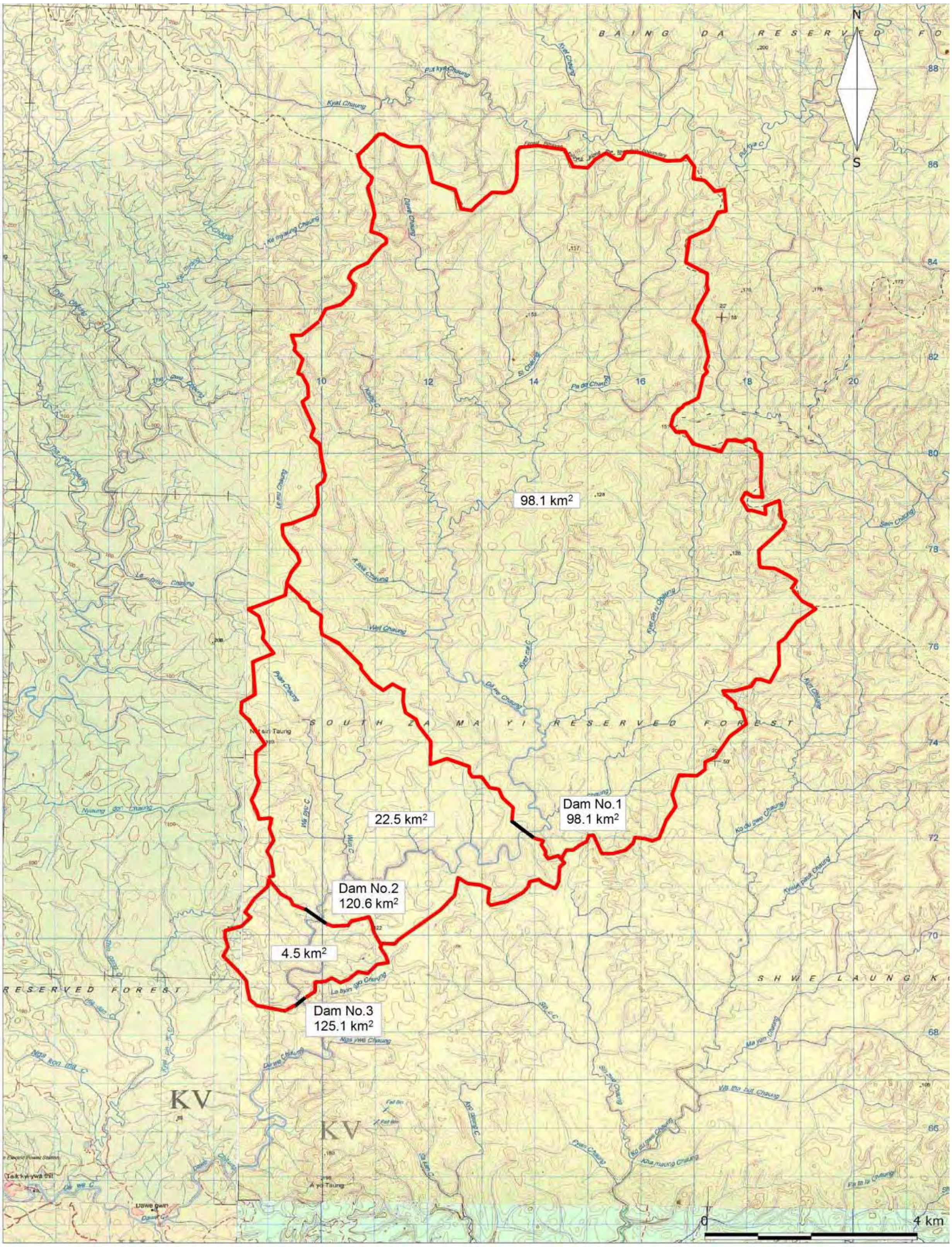


Figure 6-4-3 Catchment Areas of Dawei Dam

6-4-2 Geology Condition

The regional geologic map for the proximity of the dam site is shown in Figure 6-4-3. The geology in the vicinity of the dam site is the upper Pegu of the Miocene; the alternation of sand and mudstone are distributed primarily. The districted layer is so-called soft rock, which becomes the foundation of many dams in the vicinity; there is no problem as the dam foundation is from 20m to 30m.

The Sagaing Fault, which is located 30 km east of the dam site, is a famous active fault running to the north and south. There are already many dams constructed around there, and there is no problem with the dam's foundation being built according to a suitable seismic design.

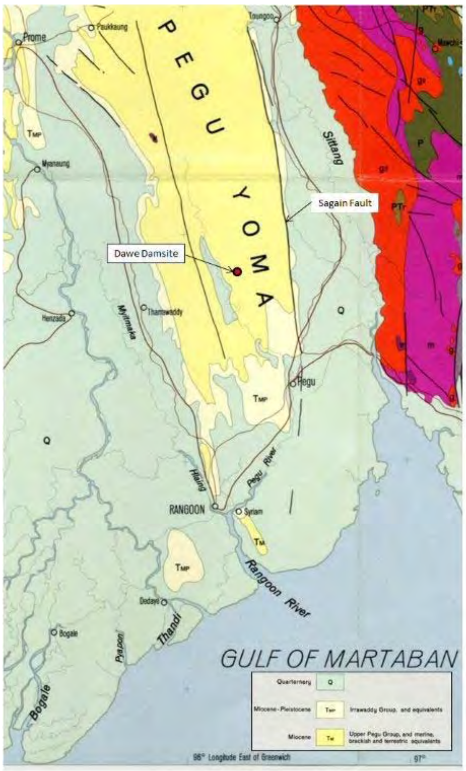


Figure 6-4-4 Geologic Map of Dawei Dam

6-4-3 Type of Dam and Embankment Material

Many existing dams in the vicinity are homogeneous fill dams. The Irrigation Department has constructed a number of dams of this type, so they have enough techniques. The construction is relatively easy for this type of dam, but the dam height is limited to the case of (normally) 30m or less because of the problems of the intensity. Because the dam height of the Dawei dam is 30m or less, the type of dam that will be considered is a homogeneous fill dam. On the other hand, with the abundance of embankment material, it is considered that there is no problem because so many of the same type of dams are constructed in similar geologic areas.

Figure 6-4-5 Dawei River

Figure 6-4-6 Dawei Bridge

Figure 6-4-7 Proposed Dam Site

Figure 6-4-8 Left Abutment at Dam Site

Figure 6-4-9 Outcrop of Shale

Figure 6-4-10 Outcrop of Shale (Soft rock)

6-4-4 Dam Capacity

The dam capacity is decided by the relation curve (H ~ Q curve) between the dam height and the dam quantity at the Dam No.3 site. The Full Water Level (F.W.L.) is EL. 91.0 m, because the dam capacity is planned as 150 MCM (See Figure 6-4-11).

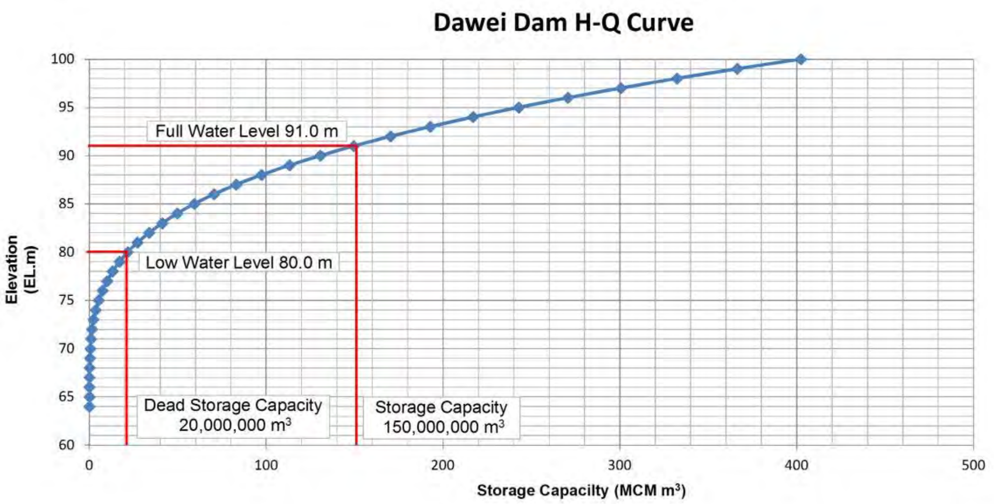


Figure 6-4-11 H ~ Q Curve at Dawei Dam Site

Table 6-4-2 List of Elevations and Volumes

Dawei Dam H-Q Curve Base Area= 12,272 ha
= 122,720,000 m^2

Elevation (m)	Area Below Elevation (%)	Area (m^2)	Average Area (m^2)	Volume (m^3)	Height
64	0.01	12272		0	
65	0.01	12272	12272	12,272	0
66	0.02	24544	18408	30,680	1
67	0.05	61360	42952	73,632	2
68	0.09	110448	85904	159,536	3
69	0.15	184080	147264	306,800	4
70	0.23	282256	233168	539,968	5
71	0.35	429520	355888	895,856	6
72	0.54	662688	546104	1,441,960	7
73	0.88	1079936	871312	2,313,272	8
74	1.21	1484912	1282424	3,595,696	9
75	1.58	1938976	1711944	5,307,640	10
76	1.88	2307136	2123056	7,430,696	11
77	2.34	2871648	2589392	10,020,088	12
78	2.82	3460704	3166176	13,186,264	13
79	3.45	4233840	3847272	17,033,536	14
80	4.12	5056064	4644952	21,678,488	15
81	4.97	6099184	5577624	27,256,112	16
82	5.7	6995040	6547112	33,803,224	17
83	6.41	7866352	7430696	41,233,920	18
84	7.32	8983104	8424728	49,658,648	19
85	8.46	10382112	9682608	59,341,256	20
86	9.65	11842480	11112296	70,453,552	21
87	10.96	13450112	12646296	83,099,848	22
88	12.26	15045472	14247792	97,347,640	23
89	13.58	16665376	15855424	113,203,064	24
90	14.82	18187104	17426240	130,629,304	25
91	16.13	19794736	18990920	149,620,224	26
92	17.66	21672352	20733544	170,353,768	27
93	18.94	23243168	22457760	192,811,528	28
94	20.32	24936704	24089936	216,901,464	29
95	21.86	26826592	25881648	242,783,112	30
96	23.5	28839200	27832896	270,616,008	31
97	25.19	30913168	29876184	300,492,192	32
98	26.81	32901232	31907200	332,399,392	33
99	28.54	35024288	33962760	366,362,152	34
100	30.17	37024624	36024456	402,386,608	35
101	31.75	38963600	37994112	440,380,720	36
102	33.11	40632592	39798096	480,178,816	37
103	34.6	42461120	41546856	521,725,672	38
104	36.32	44571904	43516512	565,242,184	39
105	37.92	46535424	45553664	610,795,848	40
106	39.56	48548032	47541728	658,337,576	41
107	41.31	50695632	49621832	707,959,408	42
108	43.14	52941408	51818520	759,777,928	43
109	44.89	55089008	54015208	813,793,136	44
110	46.54	57113888	56101448	869,894,584	45

6-4-5 Flood Discharge

The data of the estimated river discharges at the Dawei Dam site (No.3) for 30 years (1984 ~ 2013) are as follows:

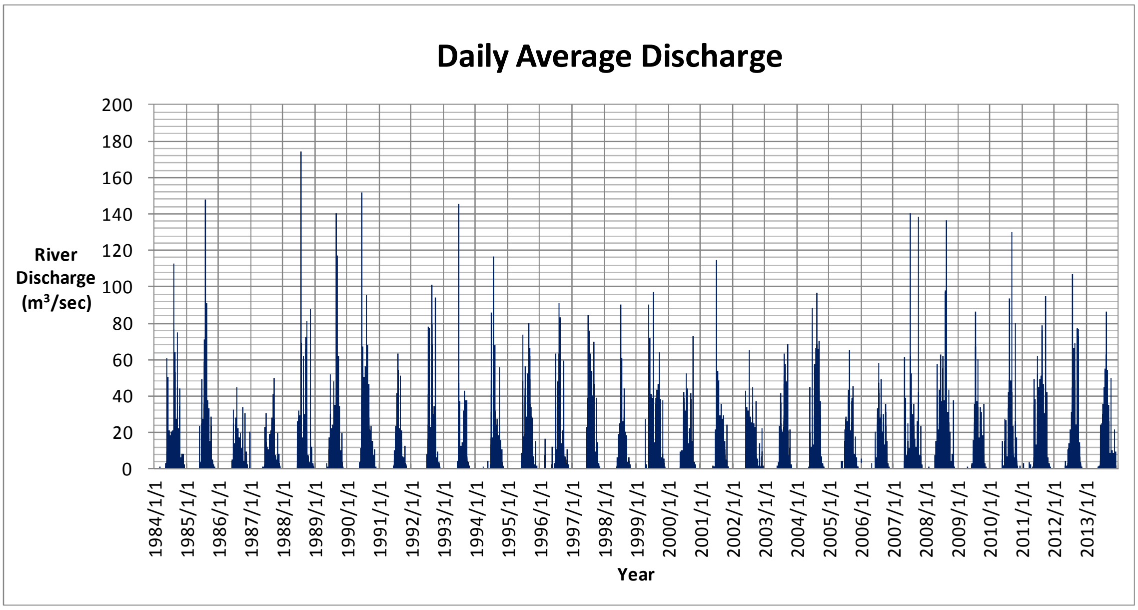


Figure 6-4-12 Estimated River Discharges at Dawei Dam Site

The catchment area at the Dawei Dam Site is 125.1 km^2 and the maximum river discharge for 30 years is 174.3 m^3/sec at 22nd July 1988.

Table 6-4-3 Maximum River Discharges for Each 30 Years

No.	Date	River Discharge (m^3/sec)	Remark
1	09 August 1984	112.80	
2	29 July 1985	147.70	
3	20 July 1986	45.00	
4	23 September 1987	49.80	
5	22 July 1988	174.30	Maximum Discharge
6	26 August 1989	140.10	
7	08 June 1990	151.80	
8	02 August 1991	63.20	
9	16 August 1992	101.50	
10	20 June 1993	145.50	
11	18 July 1994	116.80	
12	23 August 1995	80.30	
13	25 July 1996	91.10	
14	29 June 1997	84.30	
15	03 July 1998	90.50	
16	12 July 1999	97.50	
17	29 September 2000	73.30	
18	25 June 2001	114.80	
19	28 June 2002	65.20	
20	10 September 2003	68.20	
21	09 August 2004	97.00	
22	15 August 2005	65.20	
23	08 July 2006	58.00	
24	07 July 2007	140.40	
25	23 August 2008	136.60	
26	21 July 2009	86.30	
27	29 August 2010	130.30	
28	29 September 2011	94.60	
29	25 July 2012	107.00	
30	17 August 2013	86.40	

6-4-6 Flood Flow Analysis

The design flood discharge should be determined on the basis of hydrometeorology surveys and analyses. The design flood level is defined as the maximum reservoir water level when the design flood discharge occurs.

The design flood discharge is the flood discharge designated for the purpose of securing the safety of the dam and is obtained by adding 20 percent to the maximum values among the followings:

(A) 200 - years flood, which statistically occurs once in 200 years, namely the return period of a flood that could occur every 200 years flood (herein after referred to as "discharge A")

(B) Maximum experienced flood discharge estimated on the basis of flood records or flood mark survey (herein after referred to as "discharge B")

(C) Maximum flood discharge estimated from hydrological or meteorological records obtained from a nearby watershed with hydro-meteorological characteristics similar to those of the subject river (hereinafter referred to as "discharge C")

The design flood discharge is the maximum flood discharge to be considered for dam design. Therefore the maximum flood, from an engineering view point, expected to occur at the given dam site shall be adopted as the design flood discharge.

(1) 200 Years Flood

There are two methods to estimate the flood discharge which statistically occurs once in 200 years. One is to estimate directly from the frequently analysis of long term records on flood discharge. The other is to estimate indirectly based on the long term records on rainfall and characteristics of flood discharge in the given watershed.

(2) Iwai Method

The Iwai method is one of probability of exceedance calculations and return periods are obtained. The statistics method is often used at the probability of the exceedance issues in Japan.

Probability of exceedance $W(x) = \frac{1}{2} \cdot (1 - F(\xi))$

Asymmetrical distribution $f(x) = \exp(-(\alpha \cdot \log \frac{x-b}{x_0-b})^2)$

Exceedance probability function

$$F(\xi) = \frac{2}{\sqrt{\pi}} \cdot \int_0^{\xi} \exp(-t^2)$$

$$\xi = \alpha \cdot \log \frac{x - b}{x_0 - b}$$

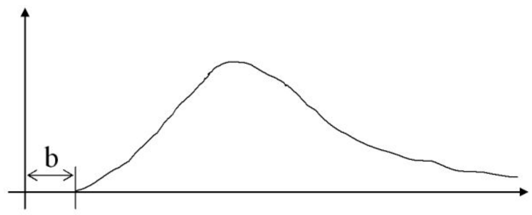


Table 6-4-4 Descending Order of Maximum River Discharges

No.	Date	River Discharge (m^3/sec)	Remark
1	22 July 1988	174.30	
2	08 June 1990	151.80	
3	29 July 1985	147.70	
4	20 June 1993	145.50	
5	07 July 2007	140.40	
6	26 August 1989	140.10	
7	23 August 2008	136.60	
8	29 August 2010	130.30	
9	18 July 1994	116.80	
10	25 June 2001	114.80	
11	09 August 1984	112.80	
12	25 July 2012	107.00	
13	16 August 1992	101.50	
14	12 July 1999	97.50	
15	09 August 2004	97.00	
16	29 September 2011	94.60	
17	25 July 1996	91.10	
18	03 July 1998	90.50	
19	17 August 2013	86.40	
20	21 July 2009	86.30	
21	29 June 1997	84.30	
22	23 August 1995	80.30	
23	29 September 2000	73.30	
24	10 September 2003	68.20	
25	28 June 2002	65.20	
26	15 August 2005	65.20	
27	02 August 1991	63.20	
28	08 July 2006	58.00	
29	23 September 1987	49.80	
30	20 July 1986	45.00	

The results of the Iwai method are shown at Table 6-4-5

Table 6-4-5 Results of Iwai Method

Return Period T year	ξ	1/a・ξ	Average: Y+1/a・ξ	x+b	Return Period Probability (m^3/sec) x
2	0	0	2.209167	161.8701	97.2
5	0.5951	0.074544	2.28371	192.1808	127.6
10	0.9062	0.113513	2.322679	210.2225	145.6
20	1.163	0.14568	2.354846	226.3844	161.8
30	1.2967	0.162427	2.371594	235.2849	170.7
50	1.452	0.181881	2.391047	246.0635	181.4
100	1.645	0.206056	2.415223	260.1494	195.5
200	1.8215	0.228165	2.437332	273.7358	209.1
500	2.035	0.254908	2.464075	291.122	226.5
1000	2.185	0.273698	2.482864	303.9936	239.4

According to the results of Iwai method, the return period discharge of a flood that could occur every 200 years is calculated at 209 m^3/sec. The design spillway discharge is 250 m^3/sec (= 209 m^3/sec × 1.2).

6-4-7 Spillway

The width of the spillway at the Dawei Dam site is calculated with the following equations.

$$Q = C \cdot L \cdot H^{(3/2)}$$

where Q: Discharge (= 250 m^3/sec: 200 years flood 209 m^3/sec × 1.2)

C: Coefficient of flow = 1.8

L: Width of spillway

H: Depth of overflow = 1.5 m

$$L = 250 / (1.8 \times 1.5^{(3/2)}) \fallingdotseq 75 \text{ m}$$

The width of the spillway is decided as 75 m for the design spillway discharge which is calculated at 250 m^3/sec.

6-4-8 Water Level of Reservoir

The water levels of the Dawei Dam are as follows:

Table 6-4-6 Specifications of Reservoir

Subject	Dawei Dam	
Catchment area	125.1	km^2
Average Annual Inflow	200.0	MCM
Type of Dam	Earth Dam	
Height of Dam	30.0	m
Length of Dam	450	m
Storage Capacity of Full Tank	150.0	MCM
Dead Storage Capacity	80.0	MCM
F.W.L.	91.0	m
D.W.L.	80.0	m
Water Spread Area of F.T.L	19.0	km^2

(1) Dam Crest Level

The calculation of dam crest level shall follow the “Engineering Manual for Irrigation and Drainage by the Japanese Institute of Irrigation and Drainage”. The Dawei Dam applies to the case of the spillway without gate and the overflow depth which is less than 2.5 m. The elevation of non-overflow section or the dam crest is decided as the value which is more than the maximum height showed in the Table 6-4-7.

(2) Wave Height from Reservoir Surface

Wave height from reservoir surface by wind shall be determined considering the relationship between the wind velocity and the fetch on design flood level, and also consideration to wave reflection and wave run-up height depending on the structural form of the dam body.

1) Fetch

Fetch is the free surface distance to wave by wind. Fundamentally it will be a distance in a straight line in the direction of maximum wind velocity.

F: fetch in km (= 8 km)

2) Wind Velocity

If no data is available on wind velocity according to long-term observation at site, it shall be in principle 30 m/sec, however, 20 m/sec may be acceptable for a dam site where there is no danger of strong wind.

V: wind velocity 30 m/sec

Table 6-4-7 Elevations of Non-Overflow Section

Dam Type	Concrete Dam	Fill Dam	
Overflow Depth Hd / Spillway Gate	―	Hd>2.5 m	Hd≦2.5 m
Dam with Spillway Gate	Hf+hw+he+0.5 (If "hw+he <1.5" is Hf+2) Hs+hw+he/2+0.5 (If "hw+he/2 <1.5" is Hs+2) Hh+hw+0.5 (If "hw <1.5" is Hh+2)	Hf+hw+he+1.5 (If "hw+he<1.5" is Hf+3) Hs+hw+he/2+1.5 (If "hw+he/2<1.5" is Hs+3) Hh+hw+1.5 (If "hw<0.5" is Hh+2)	Hf+hw+he+1.5 (If "hw+he<1.5" is Hf+3) Hs+hw+he/2+1.5 (If "hw+he/2<1.5" is Hs+3) Hh+hw+1.5 (If "hw<0.5" is Hh+2)
Dam without Spillway Gate	Hf+hw+he (If "hw+he<2" is Hf+2) Hs+hw+he/2 (If "hw+he/2<2" is Hs+2) Hh+hw (If "hw<1" is Hh+1)	Hf+hw+he+1 (If "hw+he<2" is Hf+3) Hs+hw+he/2+1 (If "hw+he/2<2" is Hs+3) Hh+hw+1 (If "hw<1" is Hh+2)	Hf+hw+he+1 (If "hw+he<1" is Hf+2) Hs+hw+he/2+1 (If "hw+he/2<1" is Hs+2) Hh+hw+1 (If "hw<1" is Hh+2)

Note

Hf、hw、he, Hs and Hd indicate the following each values.

Hf: Full Water Level (Unit: m

Hs: Surcharge Water Level (Unit: m)

Hh: Design Flood Level (Unit: m)

Hw: Wind induced wave height from reservoir surface (Unit: m)

He: Earthquake induced wave height from reservoir surface by earthquake (Unit: m)

Hd: Overflow depth when design flood discharge overflow spillway (unit: m)

3) Roughness of Slope

Smooth surface slope is a relative even surface slope which is made of concrete block or stone pitch. The Dawei Dam is riprap slope in order to absorb wave force between rock fragments.

4) Slope of Dam

In the case of riprap, wave run-up height is not affected by slope, but for the case of smooth surface slope, such depends on the steepness of slope and fetch. As a result, no consideration is required for riprap slope in determining wave run-up height, but for the low dam with smooth surface slope, the steeper the slope, the greater the wave run-up height.

Slope of dam (the upstream side): 1:3.0

Approximate value of wave run-up height R shall be found as shown in Figure 6-4-13 which shows the relationship between wave run-up height and other factors such as wave height and wave length obtained by S.M.B method, and upstream slope, and slope protection materials by the Saville method.

Freeboard for wind action would be decided by using Wave run-up height by Wilson's improved formula in S.M.B method and Saville method.

For the reasons mentioned above, the wave height from reservoir surface is decided as follows:

Wind height: 1.4 m

(3) Wave Height from Reservoir Surface by Earthquake

Freeboard for earthquake shall be calculated by using Seiichi Sato Formula as follows.

$$\mathrm{he} = \frac{1}{2} \cdot \frac{\mathrm{K} \cdot \tau}{\pi} \cdot \sqrt{\mathrm{g} \cdot \mathrm{H}_0}$$

Where,

he: wave height from reservoir surface by earthquake in meter

K: Design seismic coefficient (=0.15)

τ: Seismic period (s); one second for most case

H0: Depth of reservoir at full water level in meter (= F.W.L. 91-65 = 26.0 m)

g: Acceleration of gravity in meter per sq-second

Then,

$$he = \frac{1}{2} \times \frac{0.15 \times 1.0}{\pi} \times \sqrt{9.8 \times 26.0} = 0.38 \quad \text{(m)}$$

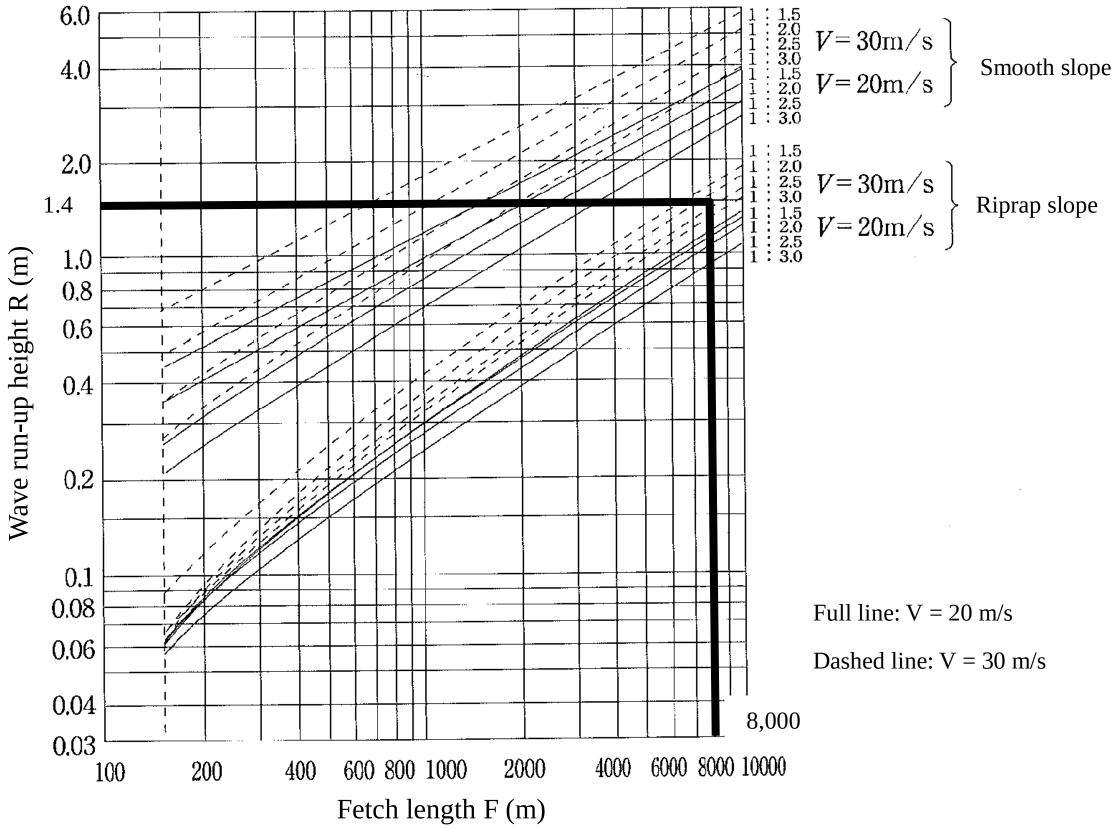


Figure 6-4-13 Wilson's Improved Formula in S.M.B and Saville Method

(4) Crest Level

The crest level shall be decided by using the "Engineering Manual for Irrigation and Drainage by the Japanese Institute of Irrigation and Drainage" standard in Japanese as follows.

CL1 = Hn + hw + he + 1 (unit: m)
CL2 = Hs + hw + he/2 + 1 (unit: m)
CL3 = Hd + hw +1 (unit: m)

Where CL1: Dam crest level based on full water level in meter
CL2: Dam crest level based on surcharge water level in meter
CL3: Dam crest level based on high water level in meter
Hf: Full water level in meter
Hs: Surcharge water level in meter
Hd: High water level in meter

Dam height------------------------30.0 m
Dam crest elevation--------------EL. 95.0 m
Full Water Level------------------F.W.L. 91.0 m
High Water Level-----------------H.W.L. 92.5 m

Table 6-4-8 Calculation of Dam Crest

(Fill dam with no gated spillway and overflow depth is less than 2.5 m)

Dam	Dawei Dam		
Spillway width	Service spillway	65.00 m	213 feet
Hn: Full Water Level		EL. 91.00 m	EL. 299 feet
Hs: Sercharge Level		-	-
Hd: High Water Level		EL. 92.50 m	EL. 303.5 feet
Over flow depth		1.50 m	4.9 feet
hw: wave height by wind	Slope: 1: 3.0 Riprap		
Wave height from reservoir surface shall be calculated by using Molitor-Stevenson Formula.	F: fetch in km	8.0	km
	V: wind velocity in km per hour	30.0	m/sec
	Wind velocity applies to the value of 30 m/sec, because there is no long term observation for wind velocity of 20 m/sec.		
	hw=	1.40 m	4.59 feet
he: wave height by earthquake	K: Design seismic coefficient	0.15	
	τ: seismic period (s),	1.00	
	H: Depth of reservoir at full water level (m)		
	Full water level F.W.L	EL. 91.00 m	EL. 298.56 feet
	Dam foundation level	EL. 65.00 m	EL. 213.25 feet
	Depth of reservoir	26.00 m	85.30 feet
	g: Acceleration of gravity	9.80	m/s2
	$he = 0.5\times K\times\tau\times\pi\times(g\times H)^{0.5}$	0.38 m	0.12 feet
Hn:Full Water Level	Hn＋hw＋he + 1.0 = if hw＋he＜1.0, Hn＋2.0	EL.93.78 m	EL. 307.68 feet
Hs: Sercharge Level	Hs＋hw＋he/2 + 1.0＝ if hw＋he/2＜1.0, Hs＋2.0	-	-
Hd: High Water Level	Hd＋hw + 1.0＝ if hw < 1.0, Hd＋2.0	EL. 94.90 m	EL. 311.35 feet
Maximum elevation		EL. 94.90 m	EL. 311.35 feet
protection thickness		0.10 m	0.33 feet
Dam crest elevation		EL. 95.00 m	EL. 311.68 feet
Minimum elevation		EL. 65.00 m	EL. 213.25 feet
Dam height		30.00 m	98.43 feet
Design dam crest elevation		95.00 m	311.68 feet
Dam crest width		5.00 m	16.40 feet

Hn＋hw＋he + 1.0＝	EL.	93.78	hw＋he	
Hn＋2.0	EL.	93.00		1.78
Hs＋hw＋he/2 + 1.0＝	EL.	-	hw＋he/2	
Hs＋2.0	EL.	-		1.59
Hd＋hw + 1.0＝	EL.	94.90	hw	
Hd＋2.0	EL.	94.50		1.40

The calculated elevation of the dam crest is EL. 95.0 m and the design freeboard is as follows:

Design freeboard = dam crest - H.W. L. = 95.0 - 92.5 = 2.5 m

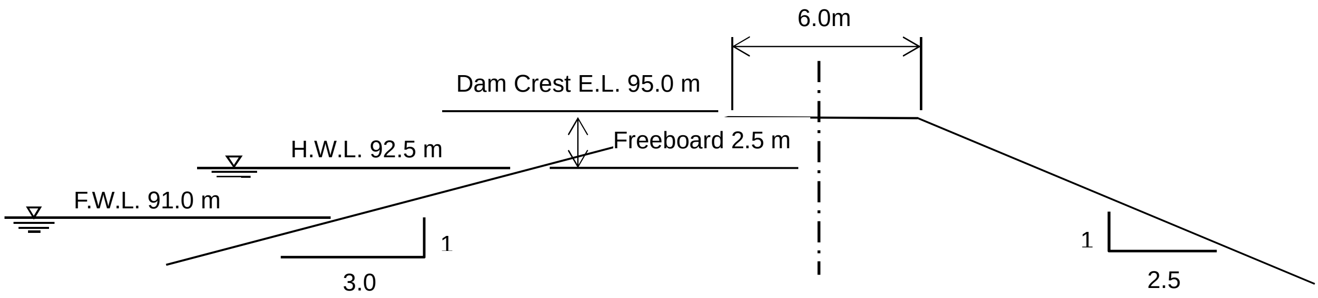


Figure 6-4-14 Dam Crest of Dawei Dam

6-4-9 Proposed Dam Cross Section

The specification and the proposed dam cross section of the Dawei dam is as follows:

Table 6-4-9 Specifications of Dawei Dam

Item		Specification	Remarks
	River name	Dawei river	
	Foundation geology	Sand stone, mud stone and Shale	
Reservoir	Catchment area	125.1 km^2	
	Average annual inflow	200 MCM	
	Reservoir area at FWL	19 km^2	
	Total storage capacity	150 MCM	
	High water level	H.W.L. 92.50 m	F.W.L. 303.48 ft.
	Full water level	F.W.L. 91.00 m	F.W.L. 298.56 ft.
	Dead Water Level	W.L. 65 m	W.L. 213.25 ft.
	Available depth	26 m	85.30 ft.
Dam	Dam type	Homogeneous	
	Dam height	30 m	98.43 ft.
	Dam length	450 m	1476.38 ft.
	Dam crest width	6.0 m	
	Dam crest level	95 m	
	Dam volume	656,000 m^3	
Spillway	Spillway type	Standard type	
	Dissipater type	Jump type	
	Discharge	250 m3/sec	200 year return period×1.2
	Weir crest water depth	1.5 m	
	Weir crest length	65 m	

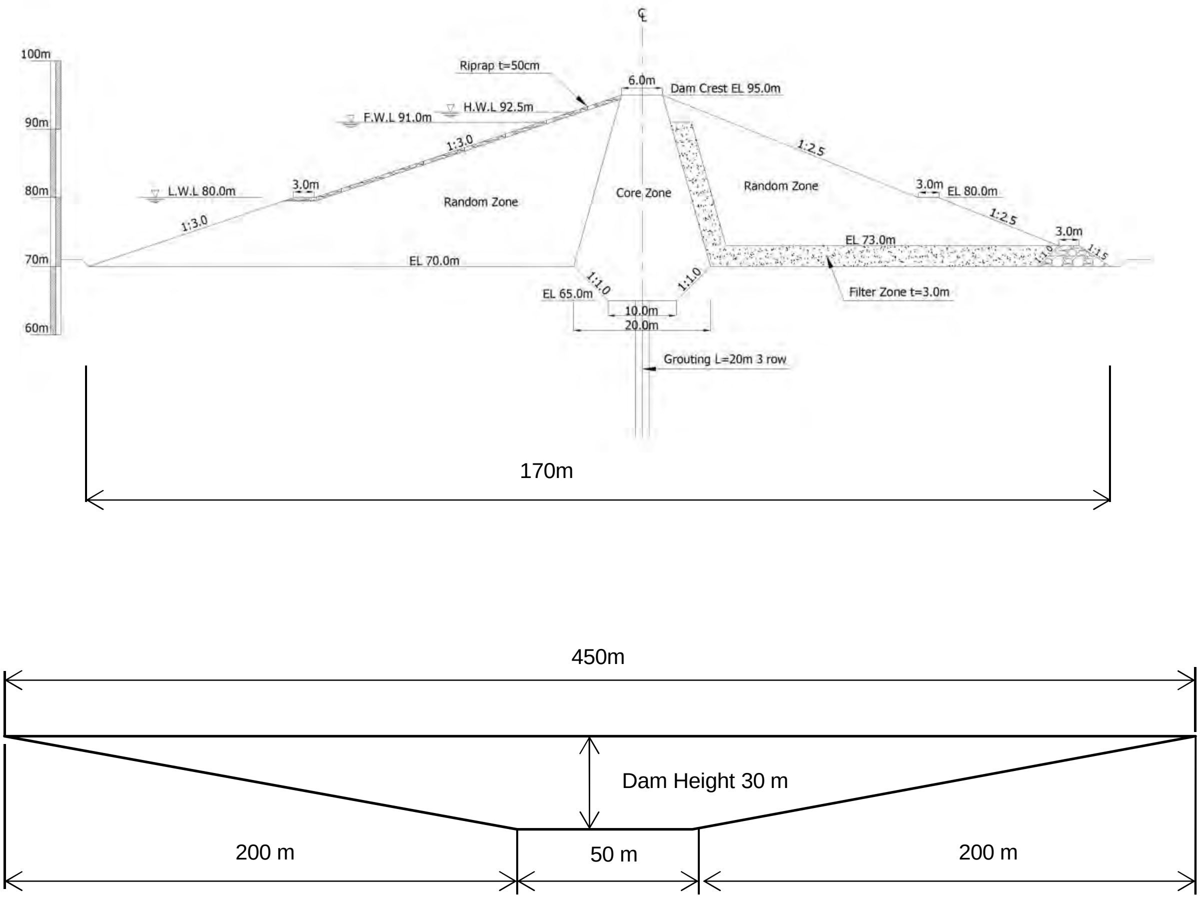


Figure 6-4-15 Typical Cross Section and Longitudinal Section of Dawei Dam

CHAPTER 7

ENVIRONMENT AND SOCIAL CONSIDERATION

CHAPTER 7 ENVIRONMENT AND SOCIAL CONSIDERATION

This chapter discusses the influence of the water resource development and implementation at the beginning of Tilawa SEZ on the natural environment and society. The project is categorized as data collection and a confirmation survey, with this report covering a part of IEE report from the legal system in Myanmar to the scoping and environmental and social considerations the survey's TOR is making. Six water resource development plans are proposed from the Project team, such as four surface water plans and two ground water plans. In these plans, three feasible plans are considered for environment and social evaluation.

7-1 Environment and Social Consideration

7-1-1 Legal System of Environment and Social Consideration in Myanmar

Before the Environmental Conservation Law was enacted in 2012, there were not overall environmental conservation laws in Myanmar. The laws related to the environment by each industrial sector functioned as environmental conservation law. Environmental conservation in Myanmar generally comes under the authority of the National Commission for Environmental Affairs (NCEA) which was established under the ministry of foreign affairs in 1990 by a surge of the interest for environmental conservation in the country. The development of the National Environmental Policy was followed by the Myanmar Agenda 21 in 1997, which follows a UN framework. In 2005, the NCEA was transferred under the ministry of forestry, and then the ministry was reformed to the Ministry of environmental conservation and forestry in September 2011. In March of 2012, the Environmental Conservation Law was enacted, which currently provides the legal basis of environmental conservation in Myanmar.

Environmental relevant laws are described below;

(1) The Forest Law (State Law and Order Restoration Council Law No. 8/92, 1992)

The Forest Law was established in 1992 because of the increase in deforestation. It aims for the appropriate management of the forest. The law clearly mentioned that the government forest policy implements environmental conservation; for instance, control of the natural resources for sustainable use conservation of biodiversity, sustainable use of forest products, etc.

(2) The Myanmar Mines Law (State Law and Order Restoration Council Law No. 8/94, 1994)

The Mines Law enacted in 1994. The objectives of the law are as follows: ①to implement the mineral resources policy of the government, ②to fulfill the domestic requirements and to increase export by producing more mineral products, ③to promote development of local arid foreign investment in respect of mineral resources, ④to supervise, scrutinize and approve applications submitted by person or organization desirous of conducting mineral prospecting, exploration or production, ⑤to carry out for the development of conservation, utilization and research works of mineral resources, ⑥to promote the environmental conservation works that may have detrimental effects due to mining operation.

(3) National Environment Policy (1994)

A National Environmental Policy was drafted by the NCEA in 1994. This policy suggests environmental conservation, such as proper utilization of water, land, forest, mineral, marine, and natural resources. According to the policy, the wealth of the nation is its people, its cultural heritage, its environment and its natural resources, and it is the responsibility of the State and every citizen to preserve its natural resources in the interests of the present and future generations.

(4) Protection of Wildlife and Conservation of Natural Area Law (No. 6/94, 1994)

This law was enacted in 1994. The law mentioned the governmental policies' implementation for wildlife such as wildlife protection, natural areas conservation, protection for endangered species and their natural habitat and establishment of zoological and botanical gardens.

(5) Myanmar Agenda 21 (1997)

The National Environment Policy was followed by the Myanmar Agenda 21. This agenda used a UN framework; it suggested a multidirectional approach for sustainable development and mentioned the needs of an environmental impact assessment.

(6) Conservation of Water Resource and River Law (No. 8/2006, 2006)

This law was enacted in 2006. The aim of this law is transportation and environmental conservation for rivers and creeks, such as the protection for the water resources and river system and assurance of smooth and safe waterways navigation. In addition, it aims to contribute to the development of the State economy through improving water resources and the river system and protecting them from environmental impact. The main chapter is chapter 5, which includes prohibited activities such as: channel shifting with the aim to ruin the water resources and rivers and creeks; wastage of water resources willfully; disposing of engine oil and other chemical or poisonous materials; etc.

(7) Environmental Conservation Law (No. 9/2012, 2012)

This mentions comprehensive environmental conservation. The objectives of this law are as follows:①to enable the implementation of the Myanmar National Environmental Policy; ②to enable the establishment of basic principles and give guidance for systematic integration of the matters of environmental conservation in the sustainable development process; ③to enable the emergence of a healthy and clean environment and the conservation of the natural and cultural heritage for the benefit of the present and future generations; ④to reclaim ecosystems, as much as possible, since they are starting to degenerate and disappear; ⑤to enable the management and implementation of beneficial and sustainable use of decreasing/disappearing natural resources; ⑥to enable the implementation of promoting public awareness and cooperation in educational programs for dissemination of environmental perception; ⑦to enable the promotion of international, regional and bilateral cooperation in the matters of environmental conservation; ⑧to enable the cooperation with government departments, government organizations, international organizations, non-government organizations and individuals in matters of environmental conservation.

7-1-2 Environmental Impact Assessment Procedure

In Myanmar, a procedure of the environmental assessment is not enforced, however, the draft of that has been formulated. According to the draft procedure, ①the project proponent shall submit a complete project proposal to the Ministry, and ②the Ministry shall determine the type of environmental assessment (EIA, IEE, or none) within 15 days after receiving the proposal.

(1) Procedure of IEE

The project has decided on requiring the IEE, which will be done by following the procedure below:

①The project proponent shall inform the Ministry in writing as to the identity of the IEE expert(s) selected to undertake the IEE investigation. ②The Ministry will check to confirm and register the expert(s) within 7 days. ③The project proponent shall undertake the public consultation process and implement the IEE. ④The IEE report shall be made based on the defined contents, and then the project proponent submitted to the Ministry. ⑤The project proponent shall disclose the IEE report to the civil society, local community and other concerned stakeholders, etc., and the disclosure shall be done not less than 10 days after the submission of the IEE report. ⑥The Ministry shall also disclose the report to the public by way of proper media channels. ⑦The project proponent shall finalize the IEE report according to all comments and recommendations and re-submit it to the Ministry. ⑧The Ministry shall make a final decision about approval of the IEE report within 60 days after receipt of the IEE report. ⑨If the project is decided to need the EIA, the EIA procedure will be done, continually. The approved project will be delivered as an ECC (Environmental Compliance Certificate).

(2) Procedure of EIA

The project has decided on requiring the EIA, which will be done by following the procedure below:

①The project proponent shall inform the Ministry in writing as to the identity of the EIA expert(s) selected to undertake the EIA investigation. ②The Ministry will check to confirm and register the expert(s) within 7 days. ③The project proponent shall submit the scoping report and the TOR for the EIA report to the Ministry according to the Ministry regulations. ④The Ministry will approve the scoping report and TOR or require the project proponent to revise these documents within 15 days of receipt of these documents. ⑤The project proponent shall undertake the public consultation process and implement the EIA. Then the project proponent submits the EIA report to the Ministry. ⑥The project proponent shall disclose the EIA report to civil society, local community and other concerned stakeholders, etc., and the disclosure shall be done not less than 10 days after submission of the EIA report. ⑦The Ministry shall also disclose the EIA report to the public and submit the EIA report to the EIA report review body for comments and recommendations. Then the Ministry shall deliver its final decision within 90 days after receipt of the EIA report. ⑧Depending on the final decision of the EIA report, the project proponent is required to amend or terminate the project. The approved project will be delivered as an ECC (Environmental Compliance Certificate).

7-2 Current Environment

7-2-1 Water Development Plans

The 6 water development plans for Thilawa SEZ are proposed by the JICA Study Team (see figure 7-2-1). Brief accounts of these are as follows:

① New well in the SEZ

This plan provides three tube wells in the SEZ. The site acquisition might be easy and is located near the end point. However, it may cause lower water table levels and water salination due to the excessive extraction of groundwater.

② New well in the Eastern Plain

This plan provides three tube wells in the eastern plain. The land acquisition is a necessity and is located far from the end point. It also has the concerns of the lower water table levels and water salination.

③ Zarmani-Inn Reservoir

This plan takes water from the existing reservoir, Zarmani-Inn. It is located 4km from the end point. It was constructed for irrigation purposes but the operation has been stopped by a governmental plan since 2012.

④ Ban Bwe Gon Reservoir

This plan also takes water from an existing reservoir, Ban Bwe Gon. It is located approximately 4km from the end point. It was also made for irrigation; it is still operating until now.

⑤ New pond in the SEZ

This plan provides some reservoirs in the SEZ. It is expected that site acquisition is easy, and it is also located quite near the end point.

⑥ Khayan River

This plan takes water from the river. This river takes a part of the 30 mile greening project which is implemented by ID. Thus, water allocation consultation is required. In addition, the intake point is located approximately 25km from Tilawa SEZ.

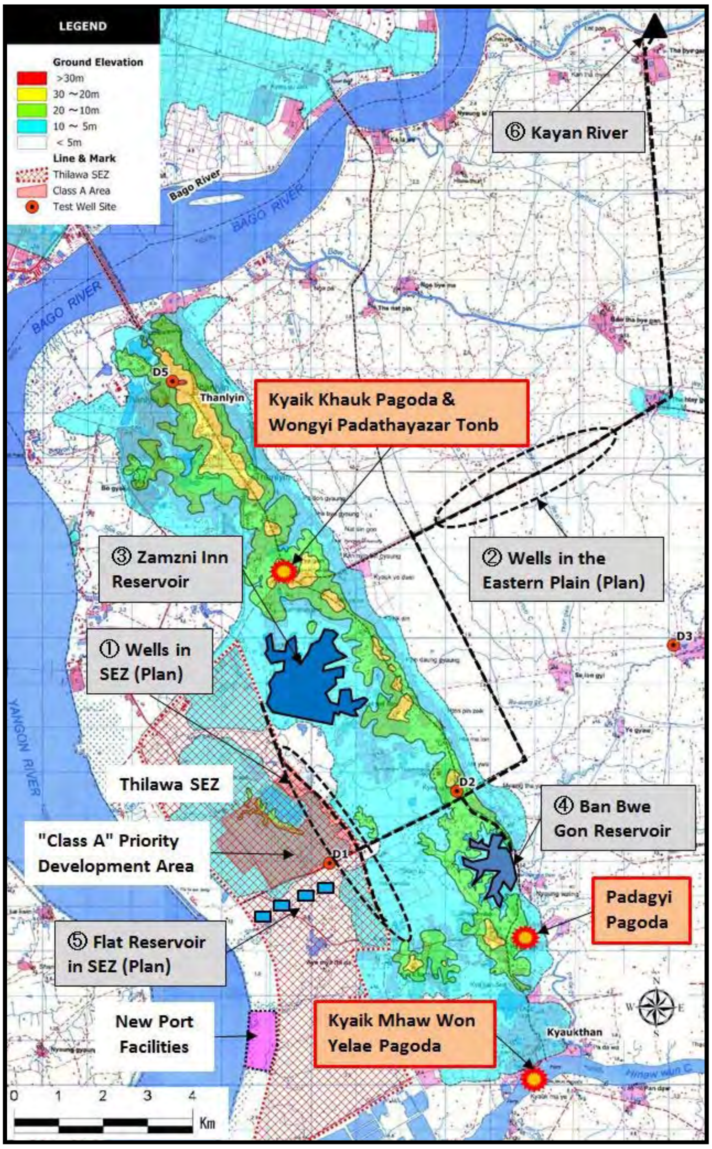


Figure 7-2-1 Location Map

7-2-2 Natural Reserve and Rare Species

According to the previous report[1] for the natural reserve and national park, these are not located around the project area. There are some descriptions of the fauna and the flora in the statistical book which is written by each township office, and the rare species are not found in the project area.

7-2-3 Cultural Heritage

The 4 cultural heritage sites are located around the project area (see fig. 2-1). *Kyaik Khauk Pagoda* and *Wongyi Padathayazar Tonb* are located in the Thanlyin township, *Padagyi Pagoda* and *Kyaik Mhaw Won Yelae Pagoda* are located in the Kyauktan township. *Kyaik Khauk Pagoda* has been declared a cultural heritage site by the Ministry of Culture since the 5th of Nov., 2009, and *Padagyi Pagoda* has been recorded as a cultural site by the Ynagon Division since the 15th of June, 2007（see fig. 2-2 to 2-4）.

[1] Myanmar Protected Areas: Context, Current Status and Challenges, ed. L. Beffasti and V. Galati, 2012.

လျှို့ဝှက်

ပြည်ထောင်စုမြန်မာနိုင်ငံတော်အစိုးရ
ယဉ်ကျေးမှုဝန်ကြီးဌာန
ဝန်ကြီးရုံး

အမိန့်ကြော်ငြာစာအမှတ် (၁၂ / ၂၀၀၉)
နေပြည်တော်၊ ၁၃၇၁ ခုနှစ်၊ တန်ဆောင်မုန်းလပြည့်ကျော် (၄) ရက်
၂၀၀၉ ခုနှစ်၊ နိုဝင်ဘာလ (၅) ရက်

ရွှေပေါင်းအထိမ်းအမှတ် အဆောက်အအုံတည်ရှိရာဇုန်သတ်မှတ်ခြင်း

အမှတ် ။ ။ ယဉ်ကျေးမှုဝန်ကြီးဌာနသည် ယဉ်ကျေးမှုအမွေအနှစ်ဒေသများ ကာကွယ်ထိန်းသိမ်းရေး ဥပဒေပုဒ်မ ၄ အရ အပ်နှင်းထားသော လုပ်ပိုင်ခွင့်ကို ကျင့်သုံး၍ အစိုးရအဖွဲ့၏ သဘောတူညီချက်ဖြင့် ရန်ကုန်တိုင်း၊ သန်လျင်မြို့နယ်၊ ဘုရားကြီးကျေးရွာအုပ်စုအတွင်းရှိ ကျိုက်ခေါက်စေတီတော်တည်ရှိရာနေရာကို ရွှေပေါင်းအထိမ်းအမှတ် အဆောက်အအုံ တည်ရှိရာဇုန်အဖြစ် အောက်ပါအတိုင်း သတ်မှတ်လိုက်သည် -

စဉ်	ဇုန်အမျိုးအစား	ပယ်နိမိတ်/နယ်မြေဒေသ	မှတ်ချက်
	ရွှေပေါင်းအထိမ်းအမှတ် အဆောက်အအုံ တည်ရှိရာဇုန် (Ancient Monumental Zone) (MZ)	- ကျိုက်ခေါက်စေတီတော်၏ ပရိဝုဏ်တစ်ခုလုံး၊ - ကျိုက်ခေါက်စေတီတော်၏ အရှေ့ဘက်ပန်းတင်ခုံမှ အရှေ့သို့လားသော ၁၃၄ ပေအကွာရှိ အရှေ့ဘက်မုခ် အထိ၊ - ကျိုက်ခေါက်စေတီတော်၏ အနောက်ဘက်ပန်းတင်ခုံမှ အနောက်သို့ လားသော ၂၄၈ ပေ အကွာရှိ အနောက်ဘက်မုခ်အထိ၊ - ကျိုက်ခေါက်စေတီတော်၏ တောင်ဘက်ပန်းတင်ခုံမှ တောင်သို့ လားသော ၂၃၅ ပေ အကွာရှိ တောင်ဘက်မုခ် အထိ၊ - ကျိုက်ခေါက်စေတီတော်၏ မြောက်ဘက်ပန်းတင်ခုံမှ မြောက်သို့ လားသော ၈၄ ပေ အကွာရှိ မြောက်ဘက်မုခ် အထိ၊	

လျှို့ဝှက်

-၂-

မာထက်ဖော်ပြပါ နယ်နိမိတ် ပိုင်းခြားသတ်မှတ်ချက်သည် ယဉ်ကျေးမှုဝန်ကြီးဌာန၏ အမှတ်အမှတ် ၂ / ၃ - ၂၀ / ၂၀၀၉ (၃၄၀၅)ရက်စွဲ၊ ၂၀၀၉ ခုနှစ်၊ အောက်တိုဘာလ (၃၀)ရက်နေ့တွင် ပါရှိသည့် မြေပုံနှင့် စာရင်းဇယားများ၌ အသေးစိတ် ဖော်ပြချက်များအတိုင်း ဖြစ်ပါသည်။

ဗိုလ်ချုပ် ခင်အောင်မြင့်
ဝန်ကြီး
ယဉ်ကျေးမှုဝန်ကြီးဌာန

စာအမှတ်၊ ၂ / ၃ - ၂၀ / ၂၀၀၉ (၃၈၆၂)
ရက်စွဲ၊ ၂၀၀၉ ခုနှစ်၊ နိုဝင်ဘာလ (၅) ရက်
ဖြန့်ဝေခြင်း
(၁) နိုင်ငံတော်အေးချမ်းသာယာရေးနှင့်ဖွံ့ဖြိုးရေးကောင်စီဥက္ကဋ္ဌရုံး
(၂) နိုင်ငံတော်အေးချမ်းသာယာရေးနှင့်ဖွံ့ဖြိုးရေးကောင်စီရုံး
(၃) အစိုးရအဖွဲ့ရုံး
(၄) တရားရုံးချုပ်
(၅) ရှေ့နေချုပ်ရုံး
(၆) စာရင်းစစ်ချုပ်ရုံး
(၇) ဝန်ကြီးဌာနအားလုံး
(၈) ရန်ကုန်မြို့တော်စည်ပင်သာယာရေးကော်မတီ
(၉) မန္တလေးမြို့တော်စည်ပင်သာယာရေးကော်မတီ
(၁၀) နေပြည်တော်စည်ပင်သာယာရေးကော်မတီ
(၁၁) ဦးဆောင်ညွှန်ကြားရေးမှူး၊ ပုံနှိပ်ရေးနှင့် စာအုပ်ထုတ်ဝေရေးလုပ်ငန်းသို့ မြန်မာနိုင်ငံပြန်တမ်း အပိုင်း(၁)တွင် ထည့်သွင်းကြော်ငြာပေးပါရန် မေတ္တာရပ်ခံချက်ဖြင့် ပေးပို့ပါသည်။
(၁၂) ရှေးဟောင်းသုတေသန၊ အမျိုးသားပြတိုက်နှင့် စာကြည့်တိုက်ဦးစီးဌာန(အပိုဒ်ခွဲ ၅ စောင်)

လျှို့ဝှက်

လျှို့ဝှက်

-၃-

(၁၃) အနုပညာဦးစီးဌာန(အပိုမိတ္တူ ၅ စောင်)
(၁၄) သမိုင်းသုတေသနဦးစီးဌာန(အပိုမိတ္တူ ၅ စောင်)
(၁၅) ပါမောက္ခချုပ်၊ အမျိုးသားယဉ်ကျေးမှုနှင့် အနုပညာတက္ကသိုလ်(ရန်ကုန်/မန္တလေး)
(၁၆) အဖွဲ့ခွဲ(၁)နှင့် အဖွဲ့ခွဲ(၃)၊ ဝန်ကြီးရုံး

အမိန့်အရ

(ကျော်ဦးလွင်)
ရုံးအဖွဲ့မှူး

လျှို့ဝှက်

Figure 7-2-2 Official Document for Kyouk Khauk Padoda given by Ministry of Culture on 5th Nov. 2009.

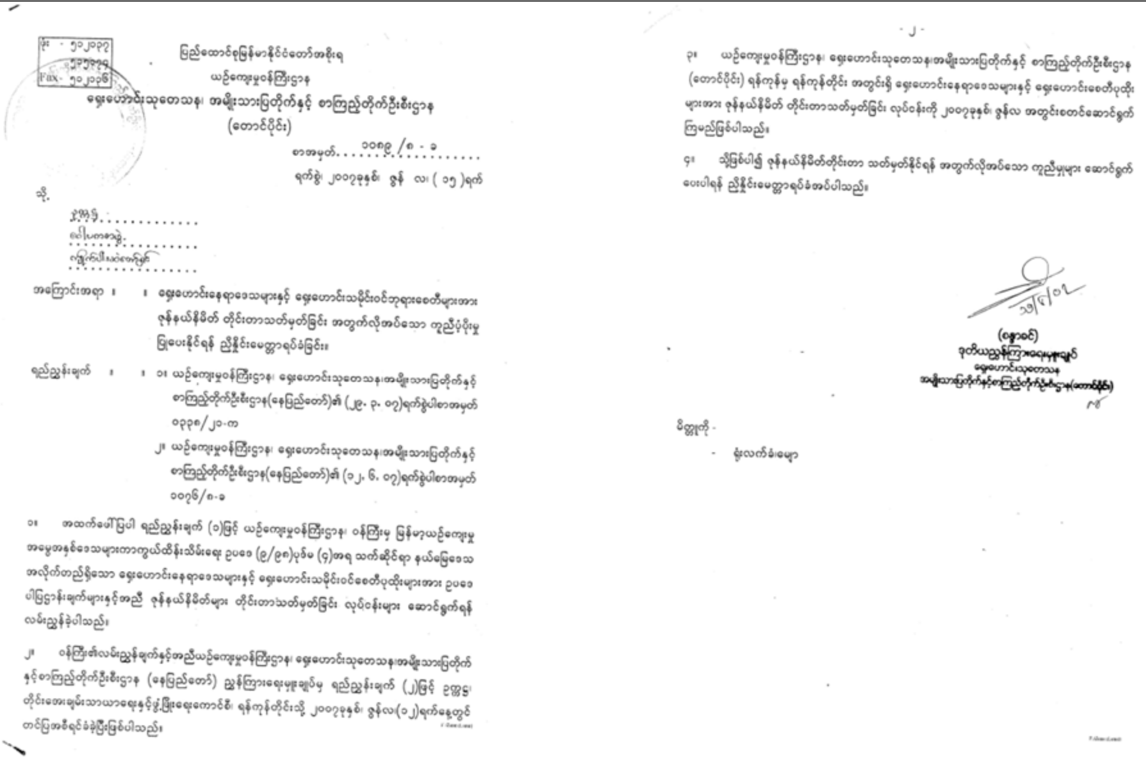


Figure 7-2-3 Official document for Padagi Pagoda given by Yangon Division on 15th Jun. 2007.

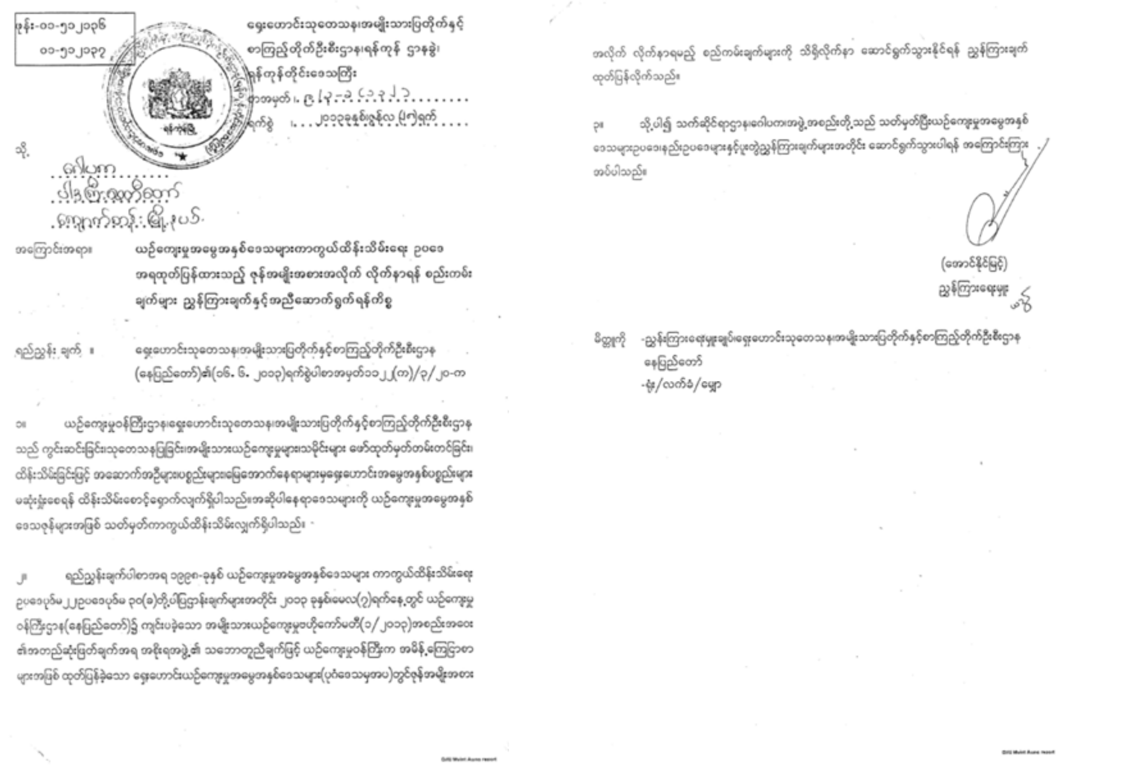


Figure 7-2-4 Official document for Padagi Pagoda given by Yangon Division on 28th Jun. 2013.

7-2-4 Existing Well and Pond

According to the result of the survey which has been done by the JICA Team, there are 14,691 wells and ponds in the project site (see Table 7-2-1).

Most of the wells are in Tanlyin and Kyautan. On the other hand, the number of ponds is higher in Thongwa and Kayan than the number of wells. According to the interview with the someone in the township general administration office, the ground water is contaminated with saline water in those townships. Thus it is difficult to find fresh water from the ground.

Table 7-2-1 Number of Wells and Ponds in the Project Area

Township	Dug well	Tube well	Pond	Total
Thanlyin	3,313	7,250	223	10,786
Kyautan	1,074	629	1,322	3,025
Thongwa	1	63	165	229
Kayan	0	79	572	651
Total	4,388	8,021	2,282	14,691

Source: JICA Study Team

7-3 Consideration Points on Water Resource Development and Implementation

7-3-1 Examination of Alternatives

As an examination of alternative plans, the following seven alternatives, including a zero-option, are examined by comparison (see Table 7-3-1). As shown in the following table, the Zamani-Inn reservoir plan (③) is the most feasible plan among the alternatives due to the viewpoint of cost and water rights. Then, the Ban Bwe Gon reservoir plan (④) and new pond construction in the SEZ plan (⑤) are considered feasible due to low LCC / m^3/day and site acquisition. The new wells construction in the SEZ plan (①) and the Kayan River plan (⑥) are also might be more feasible than the new well in the Eastern Plain, with a low LCC/m^3/day.

Table 7-3-1 Examination of Alternative Water Resource Plans

Alternative plans	**Option 0 (No Project)**	**①New well in the SEZ**	**②New well in the Eastern Plain**	**③Zamani-Inn Reservoir**	**④Ban Bwe Gon Reservoir**	**⑤New pond in the SEZ**	**⑥Khayan River**
Water Resource	－	Ground	Ground	Surface	Surface	Surface	Surface
Water Capacity / day	－	1,000m^3	1,000m^3	6,000m^3	2,900m^3	4,000 m^3	4,000m^3
Water Right Counsel	－	Unnecessity	Unnecessiity	Done	Necessity	Unnecessiity	Necessity
Site Acquisition	－	Unnecessiity	Necessity	Unnecessiity	Unnecessity	Unnecessiity	Necessity
Length of Pipe line	－	approximately 5km	approximately 16km	approximately 4km	approximately 4km	－	approximately 25km
Initial Cost (Million Yen)	0	230	473	498	375	1,356	1,470
Maintenance and Operation cost (Million Yen)	0	1.2	1.7	2.3	2.3	0	12.4
LCC (Million Yen)	0	557	1,058	1,094	850	1,356	2,782

Alternative plans	Option 0 (No Project)	①New well in the SEZ	②New well in the Eastern Plain	③Zamani-Inn Reservoir	④Ban Bwe Gon Reservoir	⑤New pond in the SEZ	⑥Khayan River
LCC/m^3/day (Million Yen)	－	0.56	1.06	0.18	0.29	0.34	0.7
Selection	×	△	×	◎	○	○	△

Source: JICA Study Team

7-3-2 Scoping

Before undertaking of the environment and social consideration survey, it is fundamental to clarify the negative impact on the environmental parameters. Based on the examination of alternatives, the Zamani-Inn reservoir plan (③), the Ban Bwe Gon reservoir plan (④), the new pond construction in the SEZ plan (⑤), the new wells construction in the SEZ plan (①) and Kayan river plan (⑥) were chosen as a scoping target. Depending on the water resource, these plans are divided into three categories of the reservoir (③, ④ and ⑤), the well (①) and the river (⑦).

Table 7-3-2 Result of Scoping：Reservoir（Surface Water）

Category		Environmental Parameters	Evaluation		Reasons
			Construction Phase	Operation phase	
Anti-pollution measures	1	Air Pollution	B-	D	**Under construction:** With regards to construction work, heavy machinery and trucks are supposed to emit exhaust gas. **During use:** Air pollution is not assumed.
	2	Water Pollution	B-	D	**Under construction:** Accompanying with construction work, heavy machinery and trucks will discharge turbid water. **During use:** Negative impact on water is not expected.
	3	Waste	B-	D	**Under construction:** Some construction waste, including soils to be moved, may be dumped during construction phase. **During use:** Once offered for use, no waste is generated.
	4	Soil Pollution	D	D	It is not expected that the work will cause any soil pollution.
	5	Noise and Vibration	B-	D	**Under construction:** The heavy machinery may make noise and some vibration around the worksite. **During use:** No noise and vibration are expected.
	6	Land Subsidence	D	D	The work's effects on land subsidence are not expected.
	7	Odor Emission	D	D	Most of the work is earthwork, thus odor emission is not expected.
	8	Bottom Sediment	D	D	The work to affect bottom sediment is not expected.
National	9	Protected Area	D	D	There are no national parks or preserved areas around the project area.
	10	Ecosystem	D	C	This project targets new well construction, and there are no rare species of animals or plants around the area.
	11	Hydrological Situation	D	C	**Under construction:** No affect to the hydrological situation is expected. **During use:** The water level of the reservoir might decline.
	12	Topography and Geology	D	D	The construction is not planed with a large scale earth work, thus the impact for topography and geology is not expected.
Social	13	Resettlement	D	D	The project site is located in the SEZ and there are no houses, so resettlement is not expected.
	14	Poverty Group	D	D	The project size is small and the site is located in the SEZ, so no impact for

Category		Environmental Parameters	Evaluation		Reasons
			Construction Phase	Operation phase	
					poverty group is expected.
	15	Ethnic Minorities and Indigenous Peoples	D	D	There are no ethnic minorities or indigenous peoples around the project site.
	16	Local Economy on Employment Opportunities and Livelihood Improvement	D	A+	**Under construction:** The project size is small, so there are few impacts on employment and the local economy. **During use:** Significant positive impact is expected by the operation of Tilawa SEZ.
	17	Land Use or local resource utilization	D	D	The project constructs the well and the supply system; impact for land use or local resource utilization is not expected.
	18	Water Use	C	B-	**Under construction:** The water of the existing reservoir is used for irrigation and homes; turbid water may occur due to construction works. **During use:** The negative impact for existing water use will be occurring due to excessive extraction of water.
	19	Existing Social Infrastructure and Social Service	B-	C	**Under construction:** Traffic jams expected during pipeline install work. **During use:** Some effects for existing water use are expected due to the over water intake.
	20	Social Institutions	D	D	No influence on social institutions is expected.
	21	Biased Benefit and Unequal Distribution	D	D	The project constructs the new reservoir or water intake facilities; biased benefit and unequal distribution is not expected.
	22	Conflicts of Interest	D	D	The works to cause conflicts of interest is not expected.
	23	Cultural Heritages	D	D	There are no cultural heritages around the work place.
	24	Landscape	D	D	Since the project carries out reservoir construction, no change of landscape will result from the work.
	25	Gender	D	D	Since the project deals with reservoir construction, the negative impact on gender is not expected.
	26	Children's Rights	D	D	Since the project deals with reservoir construction, the negative impact on children's rights is not expected.
	27	Inflectional Diseases	D	D	Since the project site is small, negative impacts for inflectional diseases are not expected.
	28	Labor Environment	C	C	**Under construction:** Careful consideration on possible accidents during the construction phase. **During use:** Careful consideration for pump operator's condition.
Other	29	Accident	B-	D	**Under construction:** Potential risk of accidents would arise from the project such as traffic accidents or injuries by heavy machinery. **During use:** No accidents expected during the operation phase.
	30	Climate Change	D	D	No climate change by the works is expected.

A+/-: Significant positive/negative impact expected, B+/-: Positive/negative impact expected to some extent, C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses), D: No impact is expected.

Table 7-3-3 Result of Scoping：Well（Ground Water）

Category		Environmental Parameters	Evaluation		Reasons
			Construction Phase	Operation phase	
Anti-p	1	Air Pollution	B-	D	**Under construction:** With regards to construction works, heavy machinery and trucks will emit exhaust gas. **During use:** Air pollution is not assumed.

Category		Environmental Parameters	Evaluation		Reasons
			Construction Phase	Operation phase	
	2	Water Pollution	B-	D	**Under construction:** Accompanying the construction work, heavy machinery and trucks will discharge turbid water. **During use:** Negative impact for water is not expected.
	3	Waste	B-	D	**Under construction:** Some construction waste, including soils to be moved, may be dumped during construction phase. **During use:** Once offered for use, no waste is generated.
	4	Soil Pollution	D	D	It is not expected that the work will cause any soil pollution.
	5	Noise and Vibration	B-	D	**Under construction:** The heavy machinery may make noise and some vibration around the worksite. **During use:** No noise and vibration are expected.
	6	Land Subsidence	D	B-	**Under construction:** No land subsidence is expected during the construction period. **During use:** Land subsidence may be caused by excessive extraction of groundwater
	7	Odor Emission	D	D	Most of the work is earthwork, thus odor emission is not expected.
	8	Bottom Sediment	D	D	The work to affect bottom sediment is not expected.
National Environment	9	Protected Area	D	D	There are no national parks or preserved areas around the project area.
	10	Ecosystem	D	D	This project targets new well construction, and there are no rare species of animals or plants around the area.
	11	Hydrological Situation	D	B-	**Under construction:** No works affect to hydrological situation is expected. **During use:** Lowering of the ground water level and water salination may be caused by over pumping.
	12	Topography and Geology	D	D	The construction is not planed with large scale earth work, thus impact for topography and geology is not expected.
Social Environment	13	Resettlement	D	D	The project site is located in the SEZ and there are no houses, so resettlement is not expected.
	14	Poverty Group	D	D	The project size is small and the site is located in the SEZ; no impact for poverty group is expected.
	15	Ethnic Minorities and Indigenous Peoples	D	D	There are no ethnic minorities or indigenous peoples around the project site.
	16	Local Economy on Employment Opportunities and Livelihood Improvement	D	A+	**Under construction:** The project size is small, so there is little impact on employment and the local economy. **During use:** Significant positive impact is expected by operation of Tilawa SEZ.
	17	Land Use or local resource utilization	D	D	The project constructs the well and the supply system; impact for land use is not expected.
	18	Water Use	D	C	**Under construction:** Negative impact is unexpected. **During use:** Existing wells around the area might be affected by over pumping.
	19	Existing Social Infrastructure and Social Service	B-	C	**Under construction:** Traffic jams expected during pipeline installs work. **During use:** Existing wells drying up expected due to the excessive extraction of groundwater.
	20	Social Institutions	D	D	No influence on social institutions is expected.
	21	Biased Benefit and Unequal Distribution	D	D	The project constructs the well and the supply system; biased benefit and unequal distribution is not expected.
	22	Conflicts of Interest	D	D	The works to cause conflicts of interest is not expected.
	23	Cultural Heritages	D	D	There are no cultural heritages around the water development construction work.
	24	Landscape	D	D	Since the project carries out well construction, no change of landscape will

Category		Environmental Parameters	Evaluation		Reasons
			Construction Phase	Operation phase	
					result from the work.
	25	Gender	D	D	Since the project deals with well construction, a negative impact on gender is not expected.
	26	Children's Rights	D	D	Since the project deals with well construction, a negative impact on children's rights is not expected.
	27	Inflectional Diseases	D	D	Since the project site is small, negative impacts for inflectional diseases are not expected.
	28	Labor Environment	C	C	**Under construction:** Careful consideration on possible accidents during the construction phase. **During use:** Careful consideration for pump operator's condition.
Other	29	Accident	B-	D	**Under construction:** Potential risk of accidents would arise from the project such as traffic accidents or injuries caused by heavy machinery. **During the use:** No accident is expected during the operation phase.
	30	Climate Change	D	D	No climate change by the works is expected.

A+/-: Significant positive/negative impact expected, B+/-: Positive/negative impact expected to some extent, C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses), D: No impact is expected.

Table 7-3-4 Result of Scoping：River（Surface Water）

Category		Environmental Parameters	Evaluation		Reasons
			Construction Phase	Operation phase	
Anti-pollution measures	1	Air Pollution	B-	D	**Under construction:** With regards to construction work, heavy machinery and trucks are supposed to emit exhaust gas. **During use:** Air pollution is not assumed.
	2	Water Pollution	B-	D	**Under construction:** Accompanying with construction work, heavy machinery and trucks will discharge turbid water. **During use:** Negative impact on water is not expected.
	3	Waste	B-	D	**Under construction:** Some construction waste, including soils to be moved, may be dumped during construction phase. **During use:** Once offered for use, no waste is generated.
	4	Soil Pollution	D	D	It is not expected that the work will cause any soil pollution.
	5	Noise and Vibration	B-	D	**Under construction:** The heavy machinery may make noise and some vibration around the worksite. **During use:** No noise and vibration are expected.
	6	Land Subsidence	D	D	The work's effects on land subsidence are not expected.
	7	Odor Emission	D	D	Most of the work is earthwork, thus odor emission is not expected.
	8	Bottom Sediment	D	D	The work to affect bottom sediment is not expected.
National Environment	9	Protected Area	D	D	There are no national parks or preserved areas around the project area.
	10	Ecosystem	D	B-	**Under construction:** The project size is small, so there are few impacts on ecosystem. **During use:** The negative impact for ecosystem will be occurring due to excessive extraction of water.
	11	Hydrological Situation	D	C	**Under construction:** No affect to the hydrological situation is expected. **During use:** The river water level might decline.
	12	Topography and Geology	D	D	The construction is not planed with a large scale earth work, thus the impact for topography and geology is not expected.
So	13	Resettlement	D	D	The project site is located in the SEZ and there are no houses, so resettlement is not expected.

Category		Environmental Parameters	Evaluation		Reasons
			Construction Phase	Operation phase	
	14	Poverty Group	D	D	The project size is small and the site is located in the SEZ, so no impact for poverty group is expected.
	15	Ethnic Minorities and Indigenous Peoples	D	D	There are no ethnic minorities or indigenous peoples around the project site.
	16	Local Economy on Employment Opportunities and Livelihood Improvement	D	A+	**Under construction:** The project size is small, so there are few impacts on employment and the local economy. **During use:** Significant positive impact is expected by the operation of Tilawa SEZ.
	17	Land Use or local resource utilization	D	B-	**Under construction:** No affect to the land use is expected. **During use:** The negative impact for fishery industry due to excessive water take.
	18	Water Use	C	B-	**Under construction:** The water of the river is used for irrigation and homes; turbid water may occur due to construction works. **During use:** The negative impact for existing water use such as irrigation will be occurring due to excessive water take.
	19	Existing Social Infrastructure and Social Service	B-	C	**Under construction:** Traffic jams expected during pipeline install work. **During use:** Some effects for existing water use are expected due to the over water intake.
	20	Social Institutions	D	D	No influence on social institutions is expected.
	21	Biased Benefit and Unequal Distribution	D	D	The project constructs the new reservoir or water intake facilities; biased benefit and unequal distribution is not expected.
	22	Conflicts of Interest	D	D	The works to cause conflicts of interest is not expected.
	23	Cultural Heritages	D	D	There are no cultural heritages around the work place.
	24	Landscape	D	D	Since the project carries out reservoir construction, no change of landscape will result from the work.
	25	Gender	D	D	Since the project deals with reservoir construction, the negative impact on gender is not expected.
	26	Children's Rights	D	D	Since the project deals with reservoir construction, the negative impact on children's rights is not expected.
	27	Inflectional Diseases	D	D	Since the project site is small, negative impacts for inflectional diseases are not expected.
	28	Labor Environment	C	C	**Under construction:** Careful consideration on possible accidents during the construction phase. **During use:** Careful consideration for pump operator's condition.
Other	29	Accident	B-	D	**Under construction:** Potential risk of accidents would arise from the project such as traffic accidents or injuries by heavy machinery. **During use:** No accidents expected during the operation phase.
	30	Climate Change	D	D	No climate change by the works is expected.

A+/-: Significant positive/negative impact expected, B+/-: Positive/negative impact expected to some extent, C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses), D: No impact is expected.

7-3-3 TOR for Environmental and Social Consideration

Based on the results of Scoping, a TOR of the environmental and social consideration survey is made for the environmental parameters which show expected negative impact or unknown impact.

Table 7-3-5 TOR for Environmental and Social Consideration

Environmental Parameters	Water Resource	Study Contents	Study Method
Air	Reservoir, Well, River	① Land and building around construction site ② Construction period and time ③ Negative effect during construction phase	① Data collection of existing data. ② Field survey ③ Data collection in other similar projects ④ Confirmation of use of heavy machinery
Water	Reservoir, Well, River	① Construction contents ② Heavy machinery use plan	① Confirmation of construction period and construction work. ② Field survey
Waste	Reservoir, Well, River	① Construction contents	① Confirmation of construction plan ② Confirmation of waste during construction phase
Noise and Vibration	Reservoir, Well, River	① Land and building around construction site ② Construction period and time ③ Negative effect during construction phase	① Existing data survey ② Field survey ③ Data collection in other similar projects
Land Subsidence	Well	① Ground water resource potential survey	① Monitoring of survey well ② Ground water model analysis
Ecosystem	Reservoir, River	① Monitoring during operation phase	① Existing data survey ② Site survey
Hydrological Situation	Reservoir, Well, River	① Water intake plan and the amount during operation phase ② Water quality monitoring during operation phase ③ Water resource potential survey	① Data collection in other similar projects ② Confirmation of water intake plan ③ Monitoring of survey well during operation phase
Land Use or local resource utilization	River	① Existing fishery industry ② Gate Operation	① Monitoring during operation phase ② Field survey and interview to local people
Water Use	Reservoir, Well, River	① Existing water use ② Water intake plan and the amount during operation phase	① Data collection in other similar projects ② Monitoring during operation period
Existing Social Infrastructure and Social Service	Reservoir, Well, River	① Existing water use ② Location and depth of existing well	① Existing data survey ② Field survey and interview to local people ③ Monitoring during operation phase
Labor Environment	Reservoir, Well, River	① Construction contents ② Heavy machinery use plan ③ Worker and working contents	① Data collection in other similar projects ② Confirmation of construction period and construction work.
Accident	Reservoir, Well, River	① Construction contents ② Heavy machinery use plan	① Confirmation of construction period and construction work. ② Confirmation of use of heavy machinery

Source：JICA Study Team

CHAPTER 8

CONCLUSION AND RECOMMENDATION

CHAPTER 8 CONCLUSION AND RECOMMENDATION

8-1 Groundwater Resources

In this survey, status of ground water resource of the targeted area was analyzed based on the existing well inventory survey, geological survey, outcrop reconnaissance, test well survey (drill, groundwater quality and groundwater head monitoring), analysis of 3D aquifer conceptual model. Observations and recommendations based on the result of the survey is as follow.

(1) Short-term water resource for Thilawa SEZ

In the surveyed four (4) townships, three (3) to four (4) aquifers suitable for production wells can be observed between 300 m depth and ground level. However, the yield of the aquifers seems insufficient with a number of low permeability layers according the the result of pumping test of the test well. Current pumping in this area reaches 16,760 m3 per day from 14,691 wells. Considering the current salty water distribution and drawdown observed in some area, careful judgment should be made for further pumping.

It is observed that two (2) to three (3) production well along the east end of the Thilawa SEZ are the most feasible for the use of ground water for Thilawa SEZ. On the other hand, salty water distribution is observed at the west side of Thilawa SEZ along the Bago River. Over pumping of ground water from the east end of the Thilawa SEZ could bring salty water distribution and drawdown to the surrounding domestic production wells. This survey analyzes the maximum volume of ground water that could be taken for three (3) years is 1,000 m3 per day from the second aquifer. Though, it should be noted that 1,000 m3 per day is based on the simulation, and actual volume that could be pumped in the future may differ from the simulation.

As a conclusion, it is recommended that the groundwater should be used as a backup resource and emergency use resource in case of natural disaster or system trouble instead of the main water resource, In case of using ground water, it is recommended to monitor the groundwater head and electric conduct conductivity, and control the volume and period of the pumping to avoid negative impact to the environment.

(2) Ground water monitoring for the Thanlyn Township

One test well (D-5) is located at center of the Thanlyin Township, which is the largest township out of the four (4) townships. According to the data from the monitoring wells, over-pumping is observed. It also shows the progress of the land subsidence. The future water demand of the survey areas will be increased with development of the region. Further pumping may salt distribution and ladn subsidence in the near future. Considering the above situation, it is advisable to conduct continuous monitoring and control of the pumping volume of ground water for Thanlyn Township.

8-2 Surface Water Resources

This survey consists of hydrological survey, water balance analysis of basin and reservoirs, etc. Observations and recommendation based on the result of the survey is as follow,

(1) Short, middle, and long term water resources

Considering the limitation of ground water resource, sustainable surface water with water quality and water volume with conveyance routes should be considered for steady development of Thilawa SEZ and adjoining areas. For the short term, surplus water of existing reservoirs in the area could be considered. And for the middle and long term, development of new surface water resource could be considered. The Bago River has a large volume of water, with an annual discharge of 3,631 MCM at the center of Bago City, even in the draught year (2010). With this back ground, Irrigation Department has built a group of dams for the purpose of irrigation along the Bago River basin. These dams contribute to the summer rice paddy cultivation in the dry season as a valuable water resource and also serve the function of flood mitigation during the rainy season to avoid long term inundation of flood waters in the Bago City areas. Summary of the water source options are as follow.

Table 8-2-1 Candidates of Surface Water Resources

	Water Resource	Required Facilities	Max. Daily water supply (m^3/day)	Remarks
Short-Term (Mid-2015)	Zarmani-inn Reservoir	Intake Facilities, φ125mm×11kw ×2 Water Conveyance Facilities, DCIP φ300mm L=4.1km	6,000	The water right of 6,000 m^3/day was accepted by the Irrigation Department at the point of time in August 2014. According to the ID, the Irrigation water requirement will be decreased by the reduction of the irrigation area. There is a possibility to convert for Thilawa SEZ 15,700 m^3/day.
	Ban Bwe Gone Reservoir	Intake Facilities, φ150mm×22kw ×1 Water Conveyance Facilities, PVC φ200mm L=4.3km	2,900	Available water is 1,400 m^3/day. Negotiation of water right is required

Mid-Term (Late 2018)	La Gun Byin Reservoir	Intake Facilities, Water Conveyance Facilities, (refer to The Project for the Improvement of Water supply, Sewerage and Drainage System in Yangon City)	42,000	Required volume of 42,000 m^3/day at entrance of Thilawa SEZ will be supplied by the master plan study for The Project for the Improvement of Water supply, Sewerage and Drainage System in Yangon City (Yen loan project with L/A in August 2014). Water right of 40 MGD (180,000 m^3/day) was recognized by ID. 10 MGD (42,000 m^3) and will be supplied to Thilawa SEZ.
Long-Term	Dawei Reservoir	New construction of dam. Intake Facilities, Intake (RC) ×1 φ350mm×300kw ×4 Water Conveyance Facilities, DCIPφ1100mm L=24.6km	78,000	Dawei Dam has 150 MCM reservoir capacity. Water conveyed to Khayan River through the main channel of a 30-mile greening project. Intake facility located at upstream of Khayan Sluice. Supply channel is required until SEZ. Multi-Purpose for water supply ① Irrigation,②Domestic,③Thilawa SEZ, additional flood mitigation. It will be able to supply water of 120,000m^3/day for 2,400 ha of Thilawa SEZ.

(2) Securement of Dam Safety

During the study for the possibility of the effective use of the surplus water in the existing reservoirs based on reservoir operation, safety of spillway and dam crest level was investigated and necessity of improvement was pointed out. (Detail is described in Appendix V 3-3 and 5-7). Further investigation and necessary countermeasure by Irrigation Department is advisable for the stable and safe dam operation.