CHAPTER 3

PRELIMINARY DESIGN OF THE PRIORITY PROJECTS

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3.1 Rehabilitation of Kaolieo Treatment Plant

3.1.1 Purpose of the Rehabilitation Works

The Kaolieo Treatment Plant was constructed in 1964 with a production capacity of 20,000 m^3/day and rehabilitated in 1983, is the oldest water treatment plant in Vientiane, therefore deterioration of facilities and equipment has become a significant problem for the stable operation of the plant. Intake pumps, distribution pumps, the flash mixer, the surface wash system and backwash pumps for filters, facilities for chemical dosage and maintenance valves for clear water reservoir were all rehabilitated in 1984. However, that was nearly 20 years ago, and other equipment and facilities in the plant are more than 40 years old.

In July 2002, both the intake amount and the amount of treated water increased because of the installation of additional intake pumps. Before the installation, 19,200 m^3/day was the maximum raw water intake, but after the installation of extra pumps, the amount of water intake increased to 33,539 m^3/day as the maximum in October 2002. After July 2002, the quantity of treated water was 26,000 to 30, 000 m^3/day and it is apparent that the plant has been operating under overloaded conditions as the design capacity of the plant is 20,000 m^3/day.

This means that the operators of the water plant are struggling against the deterioration of machinery without sufficient spare parts under overloaded conditions while trying to meet an increasing water demand. Therefore, in order to secure water supply to the existing service area from the Kaolieo Treatment Plant, it has been judged that the rehabilitation works for the Kaolieo Treatment Plant is indispensable and selected as a priority project. The rehabilitation works of the existing Kaolieo Treatment Plant are as follows.

3.1.2 Intake Facilities

(1) Intake Pumps

In 2002, since the efficiency of the existing intake pumps in the intake tower lowered, additional intake pump was installed on a floating dock which is moored just upstream of the existing intake tower. To evaluate the existing pump condition, the JICA Study Team measured the discharge flow rate from the intake pumps and the distribution pumps by using an ultrasonic flow meter.

Based on the results of the measurement, the pump capacity is calculated at about 6 m^3/min. However, the rated capacity of these pumps is 7.65 m^3/min. Therefore the current operating efficiency of the intake pumps is 22 % less than is achievable.

Therefore, the three existing intake pumps in the intake tower are recommended to be replaced with new pumps having the same specification.

(2) River Bank Protection

Although it is not confirmed whether the intake tower causes erosion to the river bank or not, serious damage to the river bank in the vicinity of the existing intake tower has been observed. Therefore, it is necessary to repair and protect the damaged river bank. A soda mattress method may be employed for protection of the foot of the bank.

(3) Maintenance Bridge

The existing maintenance bridge to the intake tower will be repainted and the wooden floor plates will be replaced with new ones.

(4) Raw Water Transmission Pipeline

As the existing raw water flow meter is inoperable, the quantity of raw water introduced to the plant is an estimate based on pump capacity and pump operating hours. To control the treatment process, especially to decide the amount of chemical feeding, the quantity of raw water is an important factor. The rehabilitation works will include the installation of a new flow meter with a flow control valve.

In addition, significant leakage and spurting water from the existing gate valves at the intake is observed even though these valves are completely open, and these valves may not be able to close completely. Therefore, such valves will need to be replaced.

3.1.3 Treatment Facilities

(1) Receiving Well & Mixing Well

In order to secure the mixing of a coagulant and the raw water, it is necessary to replace the existing rapid mixer which is 20 years old with a new mixer.

(2) Flocculation Basin

Repairs to the existing concrete walls are necessary, since cracks and leakage from cracks are observed in the concrete walls of the treatment facility especially at the flocculation and sedimentation basins. In addition some concrete baffle walls for the vertical baffling flow are broken and damaged and have been replaced with temporary wooden walls. Therefore it is necessary to replace the baffle walls.

(3) Sedimentation Basin

The gravel filter layer is installed at the effluent of sedimentation basin at the Kaolieo Treatment Plant. Maintenance work of the gravel layer is conducted by the staff of Kaolieo Treatment Plant and the maintenance works include washing the layer by pressurized water from its surface since layer washing pipe has not been function and sometimes gravel is removed from layer and it is washed manually outside of the basin.

Since the maintenance works are very burden and the effects of the layer is questionable, the Study Team investigated the effects of the gravel layer by measuring turbidity before and after the gravel layer. If the turbidity after the gravel layer is decreased one before the layer, the gravel layer will be evaluated as effective.

Turbidity was measured two times each on October 6 and October 16 and the results of the measurements are shown below.

Results of Turbidity Measurements before and after the Gravel Filter

	October 6		October 16	
Turbidity measurement	No. 1	No. 2	No. 3	No. 4
Condition of the gravel layer	ordinary condition	gravel was removed from gravel filter	ordinary condition	just after gravel washing by pressurized water from the layer surface
before gravel filtration	5.8	6.3	6.5	6.5
after gravel filtration	8.2	6.5	7.8	5.8

As shown on table above, under the ordinary condition, measurements No. 1 and No. 3, turbidity after the gravel filtration are higher than ones before the filtration. This turbidity increase may caused by discharging turbidity from the gravel layer which has been accumulated in the layer.

It is observed that turbidity is increased even though the gravel was removed from the filter layer. This may be because of the turbulent flow caused by structure of the gravel filter. If the gravel is placed in the layer, water flow will be regulated by the gravel.

Only from the measurement results of No. 4, decrease of turbidity after the gravel filtration. This is because the gravel layer was clean by the recent washing. However, reduction of the turbidity is rather smaller than expected.

Taking account of frequency of gravel washing and such burden maintenance work, the efficiency of the gravel filtration is judged not so high. Therefore, it is recommended to remove gravel filter during the rehabilitation work on the existing Kaolieo Treatment Plant.

(4) Filter Basin

The facilities and equipment installed in the filtration basins is 40 years old. There is not enough filter media and sand for proper filtration because of sand wash-out during the back-washing process. Control of the back wash rate and the surface wash rate for the filtration basin is almost impossible at present because the butterfly valves on these lines are malfunctioning. An appropriate interval for the back-washing process is not kept because the head-loss meter is also inoperable. In addition, the installation of a filtered water flow meter is proposed for deciding the chlorine feeding concentration.

Therefore, the rehabilitation works for the filtration process includes:

a. replacement of the filter media and repair of the under-drain system,
b. replacement of surface washing system,
c. replacement of head-loss meter, piping, valves and gates,
d. replacement of backwash pumps, and
e. installation of filtered water flow meter.

3.1.4 Chemical Feeding Facilities

All the chemical dosage pumps and flow controllers malfunction and the chemicals are dosed by gravity. This makes it difficult to achieve accurate chemical dosage control. The existing chemical feeding facility will be integrated as a part of the new chemical feeding facilities which will be constructed during the expansion works.

3.1.5 Distribution Facilities

(1) Clear Water Reservoir and Distribution Pump Building

These facilities are not necessary to be rehabilitated as one of the priority projects.

(2) Distribution Pumps

To evaluate the existing pump condition, the JICA Study Team measured the discharge flow rate from the distribution pump by using an ultrasonic flow meter. Based on the results, the discharge of the distribution pumps was measured at 5.3 m^3/min/unit. Considering that the design capacity of the distribution pumps is rated at 6.3 m3/min/unit, the distribution pumps which are 20 years old, are working at a reduced capacity. Therefore, the four existing distribution pumps in the distribution pump building need to be replaced with new pumps.

3.1.6 Electrical Facilities

The power sub-station in the existing Kaolieo Treatment Plant was constructed in 1964, and much of the equipment and facilities are now 40 years old. The power sub-station receives power through a single electric power supply line from the Lao Electric Company. The Kaolieo Treatment Plant sustains great losses every year due to many power failures, as shown in Annex 9. The rehabilitation works for the electrical facility of the plant includes:

a. replacement of power receiving and transformer equipment,
b. replacement of power supply equipment,
c. new installation of a generator for emergency power during the power failures, and
d. replacement of instrumentation equipment.

The rehabilitation of the electrical facility is considered to be included in the expansion of the Kaolieo Treatment Plant, and the new facility constructed by the expansion works will be shared for the existing and new facilities.

3.1.7 Other Facilities

(1) Administration and other Buildings

The existing administration buildings, warehouses and the alum storage house which are located at the site of the proposed expansion, should be demolished and relocated within the existing plant premises.

(2) Laboratory

The Kaolieo Treatment Plant conducts water quality analysis once a month at the laboratory. The items of water quality analysis are almost same as the Chinaimo Treatment Plant. The equipment installed and functioned in the laboratory includes only a turbidity meter, an incubator, a balance, a pH meter and an oven. Most of the equipment is broken or the sensors of the equipment do not function. Almost all water quality tests except pH and turbidity are measure by means of a “Pack Test” which is a simple type of a disposable water quality test kit.

In order to maintain proper water quality control at the Kaolieo Treatment Plant, the laboratory equipment should be furnished with functioning equipment. As with the chemical feeding and electrical facilities, the laboratory with adequate equipment will be provided during the expansion works.

The major work items of the rehabilitation works for the existing Kaolieo Treatment Plant are summarised in Table 31-1.

Table 31-1 Rehabilitation Work of Existing Kaolieo Treatment Plant

Name of Facility	Name of Component		Specifications
Intake Facilities	Intake Pump	Replace	7.65 m3/min×19.5 m×37 Kw×3 Units
			Check and Sluice Valves with Motorized Operation
	Butterfly Valve	Replace	D500mm with Motorized Operation for Flow Control
	Crane	Replace	Electric Hoist Crane
	Maintenance Bridge	Repair	
	Bank Protection	Improve.	River Bed and River Bank Protection: L=45 m
Raw Water Transmission Pipe	Flow Meter & Control Panel	Replace	Ultrasonic Flow Meter at Maintenance Bridge
			Flow Control Panel
Mixing Well	Flash Mixer	Replace	Repairing the Structure and Valves if necessary
Flocculation & Sedimentation Basins	Flocculation Basin	Replace	D400mm of Inlet Valves
			D250mm of Sludge Drain Valves
			Up and Down Flow Baffle Walls
	Sedimentation Basin	Improve.	Substitute Outlet Launders for Gravel Filter
		Replace	D150mm of Drain Valves
		Improve.	Pressurized Cleaning Piping System
		Repair	Structural Wall's Clacks
Filtration Facilities	Filter Media	Replace	Effective Size=0.6mm, Depth of Sand=0.70m
	Underdrain System	Improve.	Precast Concrete Perforated Lateral System
	Operating Valves for Filtration	Replace	Inlet & Outlet Valves with Motorized Operating Stand
		Replace	Motorized Drain, Backwash & Surface Wash Valves
		Replace	Flow Controller
	Surface Wash System	Improve.	Surface Wash Equip. and Flow Meter & Control Valves
	Backwash Pump	Replace	27.1 m3/min×55 Kw×2 Units
Clear Water Reservoir		Repair	Repairing the Structure and Valves if necessary
Distribution Facilities	Distribution Pump	Replace	6.3 m3/min×67 m×110 Kw×4 Units
		Replace	Check and Sluice Valves with Motorized Valves
		Replace	Vacuum Pump and Incidental Accessaries
	Hoist Crane	Replace	Electric Hoist Crane
	Distribution Pipe	Improve.	D450mm×65 m
Chemical Feeding Facilities	Chemical Building	New	Located in the Expanded Administration Building
	Feeding Equipment & Solution Tank	New	Aluminium Sulfate in the Chemical Building
		New	Polymer in the Chemical Building
		Replace	Calcium Hypochlorite at the Clear Water Reservoir

Name of Facility	Name of Component		Specifications
Electrical Facilities	Power Receiving Facility	Replace	Using the Expanded Power Receiving and Transformer Equipment
	Power Supply Facility	Replace	Intake Pump Control Panel
		Replace	Distribution Pump Control Panel
		New	Operation of Filtration Control Panel
		New	Central Supervising Panel
	Emergency Generator Facility		Located in the Expanded Generator Room
			Generator Capacity for 1/3 Distribution Pump Capacity
	Instrumentation Facility	New	CRT Supervising Equipment
		Replace	Intake Level Meter
		Replace	Raw Water Flow Meter (Ultrasonic Type)
		New	Filtered Water Flow Meter (Oriffice Type)
		Replace	Head Loss Meter
		Replace	Clear Water Reservoir Level Meter
		Replace	Pressure Meter of Distribution Line
		Repair	Distribution Flow Meter(Ultrasonic Type)
Administration Building			Using the Expanded Administration Building
Laboratory			In Preparation for Expanded Administration Building
Landscaping and Others			Site Preparation, Embankment, Roads, Lighting, etc.
			Including Demolision and Relocation of the existing housings

3.2 Improvement of Chinaimo Treatment Plant

3.2.1 Purpose of the Improvement

The Chinaimo Treatment Plant, with a rated capacity of 40,000 m^3/day, was constructed in 1980 with finance provided by the ADB. During 1992 - 1996, rehabilitation and expansion works were implemented by Japan's Grant Aid and the total capacity was expanded to 80,000 m^3/day. Compared with the Kaolieo Treatment Plant, the condition of facilities and equipment at the Chinaimo plant are better.

The Chinaimo Treatment Plant was originally designed for water to be transmitted to elevated tanks and reservoirs throughout the town. Therefore, the total capacity of the pumps in the Chinaimo Treatment Plant is 80,000 m3/day, the same as the plant capacity. This means that the plant is not able to distribute water which has hourly fluctuations. Accordingly, the capacity of reservoirs is about 3,000 m3, equivalent to less than 1 hour of plant production capacity.

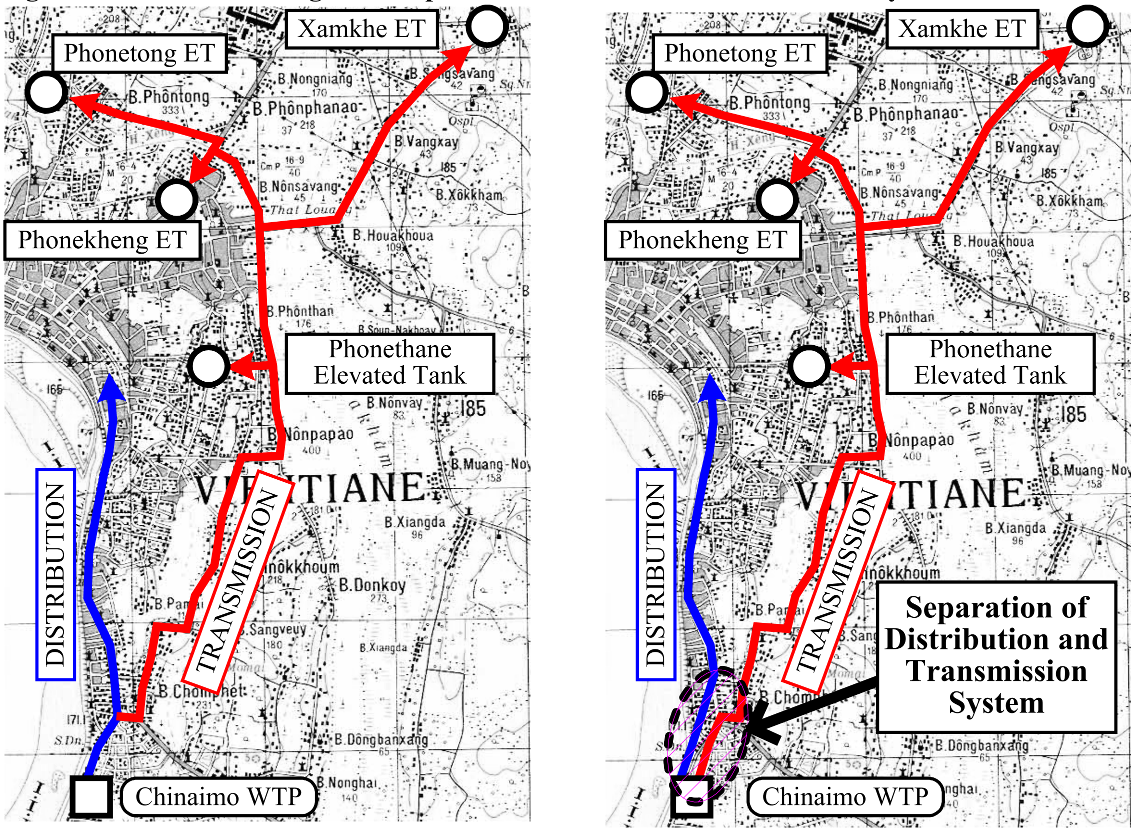
Although the plant was designed only for transmitting water to the elevated tanks and reservoirs, distribution lines are branched from the transmission pipeline to distribute water directly throughout the town. A flow measurement survey was carried out from March to April 2003 during the Phase I: Reconnaissance Survey, in order to measure the amount of distributed and transmitted water supplied from the Chinaimo Treatment Plant. The results of the survey are summarised in Annex 10. Based on these results, the amount of water distributed is about 50 % of the total treated water, i.e. 40,000 m3/day. Because of the mixture of the distribution and transmission systems, the distribution system can not meet hourly fluctuations and consequently the transmission system becomes unstable depending on the quantity of distributed water.

Given these conditions, it is considered that the separation of the systems is indispensable to achieve a stable distribution and transmission system for delivering water. For this system separation to be achieved

a. the expansion of the distribution reservoir capacity, 10,000m3,
b. the installation of distribution pumps to meet hourly demand fluctuations,
c. the installation of an independent transmission main from the plant to the branch point of the existing transmission pipeline, approximately 0.7km of a 700mm dia. pipeline, and
d. the construction of the associated electrical facilities,

is required. After the system separation, half of the plant capacity, 40,000 m3/day, will be reserved for the transmission system and the remaining 40,000 m3/day will be reserved for the distribution system. For the transmission system, the existing pumps will be utilized. Figure 32-1 shows the present and proposed distribution and transmission systems of the Chinaimo Treatment Plant.

Figure 32-1 Existing and Proposed Distribution and Transmission System



Existing Distribution and Transmission System　　Proposed Distribution and Transmission System

3.2.2 Clear Water Reservoir

After the separation of the systems, the existing reservoir will be reserved for the transmission system and a new reservoir will need to be constructed for the distribution system. The capacity of the new additional reservoir will be 10,000 m3, which is equivalent to 6 hours of the distribution capacity. Since the effective depth of the existing reservoir and pump suction pit are rather shallow, at 2.7 m, the new reservoir will occupy a large space in the plant if the system is designed to the same hydraulic conditions. Therefore, the new reservoir and additional distribution pumping systems are planned to have separate hydraulic conditions to save land space.

3.2.3 Distribution Pumping Facilities

In order to meet the hourly fluctuations in water demand, the distribution pumps are planned in consideration of the hourly peak factor of 1.3. The peak factor is calculated from the results of flow measurement survey attached in Annex 10. The basis of these calculations is shown in Annex 15.

The type of distribution pumps to be installed will be a double suction volute pump (centrifugal pump) which is suited for a middle range of pumping head and relatively large flow rate. This type of pump is the most popular for distribution and transmission pumps of waterworks. The control of the distribution flow rate is achieved by the control of the number of operating pumps, not by the revolving speed control. The specification of the distribution pumps is 12.1 m3/min x H 67.0 m x 4 units including one stand-by pump.

3.2.4 Electrical Facilities

The electrical facility including power receiving equipment, transformer, power supply equipment, emergency generator and instrumentation equipment, will be constructed corresponding with the distribution pump facility.

3.2.5 Transmission Pipeline

As shown in Figure 32-1 the installation of individual transmission pipelines from the Chinaimo Treatment plant to the branch point of the existing transmission pipeline is required for the system separation. The diameter of the existing transmission pipeline is 700 mm so the proposed pipeline diameter will also be 700 mm. According to the network analysis shown in Annex 25, water from the Chinaimo Treatment Plant can be transmitted to the elevated tanks and ground reservoirs through the proposed transmission pipeline of diameter 700 mm.

At the master plan stage, the length of proposed transmission pipeline was estimated at 0.6 km. However in considering the location of the connection point with the existing transmission pipeline, and the results of the survey, the length of the pipeline is required to be 0.7 km.

3.2.6 Others

When the new reservoir is constructed in the vacant area on the western side of the existing reservoir, the existing pipeline of 1,000 mm dia. and 300 mm dia., crossing the vacant area will obstruct the reservoir construction. Therefore, the 1,000 mm and 300 mm pipelines should be relocated as shown in Figure 32-3.

The general plan of Chinaimo Treatment Plant is shown in Figure 32-2. The major work items of the improvement works for the existing Chinaimo Treatment Plant are summarised in Table 32-1.

Figure 32-2 General Plan of Chinaimo Treatment Plant

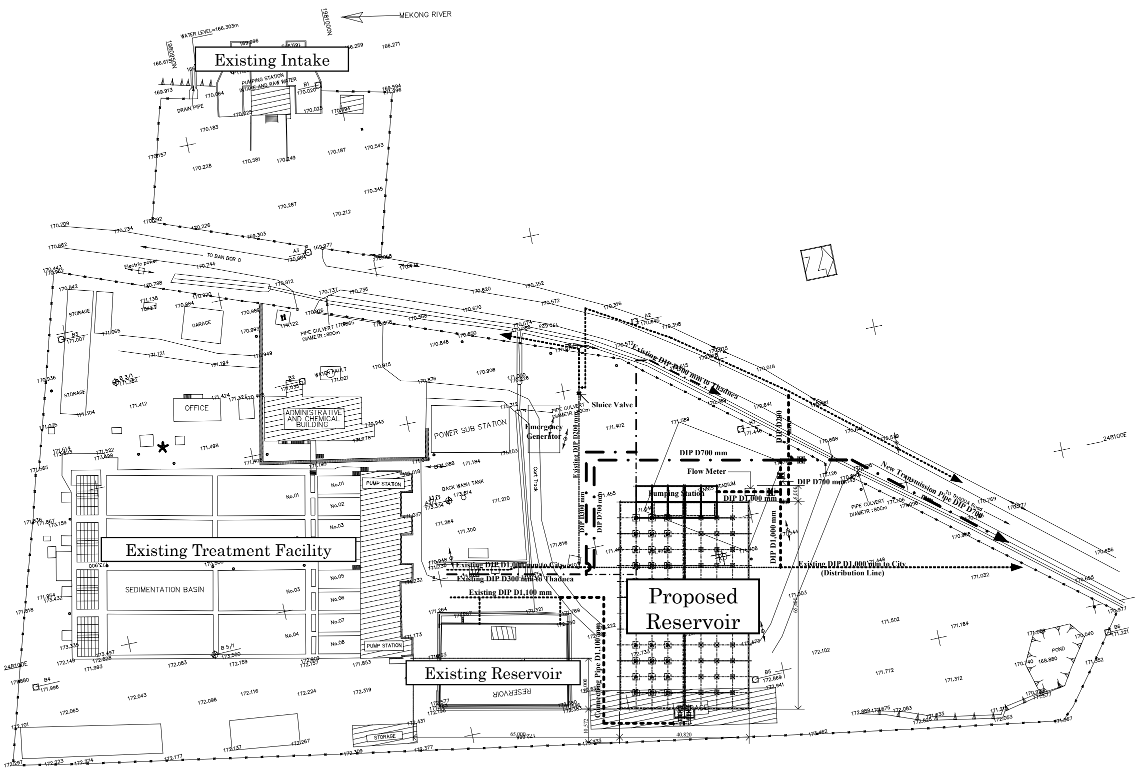


Figure 32-3 Yard Piping Arrangement for Improvement of Chinaimo Treatment Plant

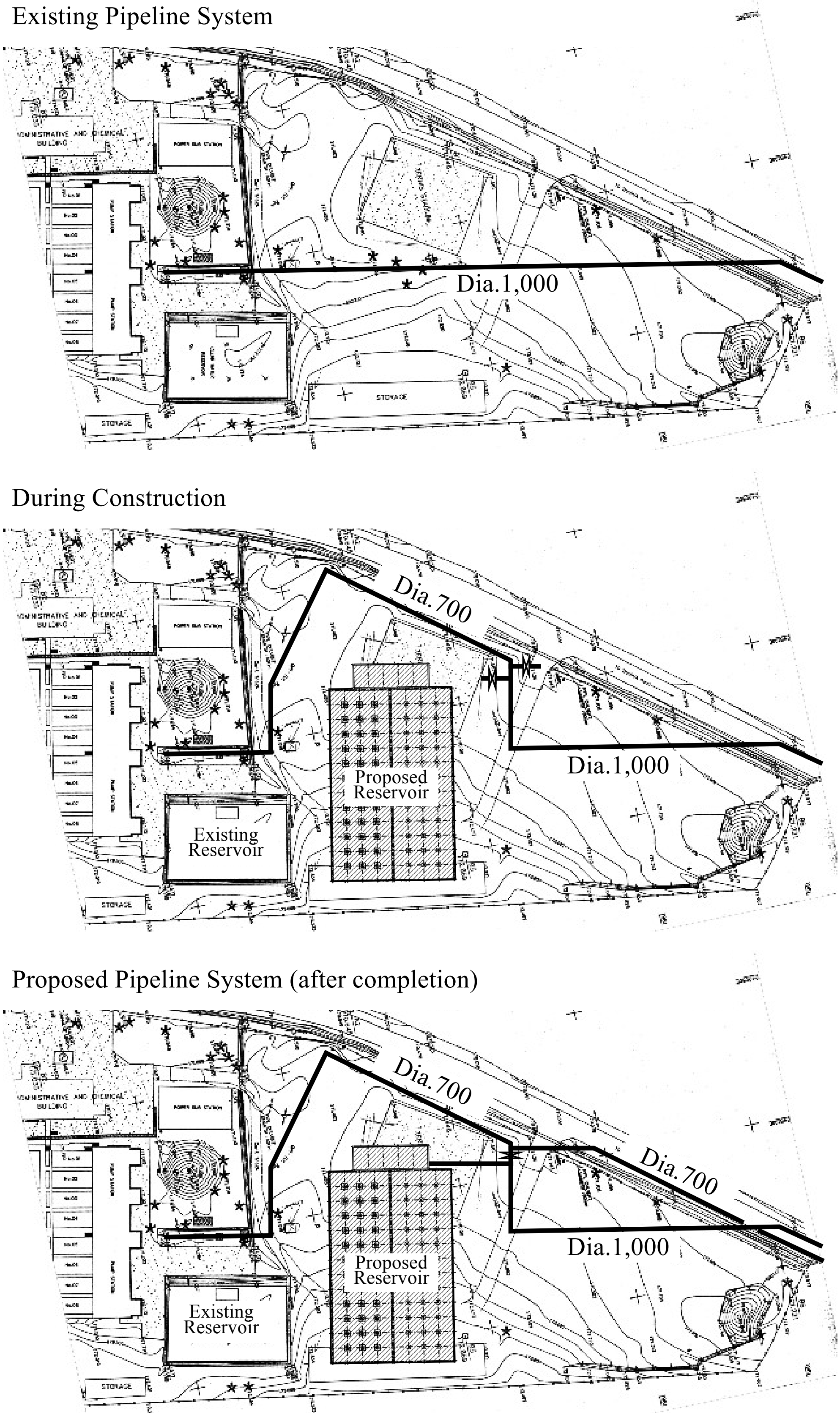


Table 32-1 Improvement Work of the Existing Chinaimo Treatment Plant

Name of Facility	Name of Component	Specifications
Clear Water Reservoir	Clear Water Reservoir	V=10,000 m3, Detention Time=6 hr
	Operating Valves and Piping	D1,100mm Butterfly Valves with Manual Operating Stand
		D800mm Butterfly Valves with Manual Operating Stand
		D1,100mm Inlet Pipe×50 m
Distribution Pumping Facilities	Distribution Pump Building	Area=250 m2 Beside the Clear Water Reservoir
	Distribution Pump	12.1 m3/min×67 m×195 Kw×4 Units
		Check and Sluice Valves with Motorized Valves
		Vacuum Pump and Incidental Accessaries
	Hoist Crane	Electric
	Operating Distribution Pipe	D700mm×76 m and D1,000mm×25 m
	Operating Valves	D700mm and D1,000mm Butterfly Valve
Electrical Facilities	Power Receiving Facility	Branch Power Source from the Existing Power Receiving and Transformer Equipment
	Power Supply Facility	Low Voltage Power Receiving Panel
		Distribution Pump Control Panel
		Supplementary Power Supply Panel
	Emergency Generator Facility	Generator Room with Fuel Tank
		Generator Capacity for 1/3 Distribution Pump Capacity
	Instrumentation Facility	Replacement the Existing Monitoring Panel
		Replacement of Ultrasonic Flow Meter for Thaduea
Landscaping and Others		Site Preparation, Embankment, Roads, Lighting, etc.

3.3 Expansion of Kaolieo Treatment Plant

3.3.1 Capacity and Component of Work

As mentioned in Chapter 2, the first stage expansion of the Vientiane Water Supply Development Project will be 40,000 m3/day to meet the day maximum water demand in 2007. The scale of the first stage expansion was decided considering adequate scale of the project among international lending agencies to avoid difficulties finding funding sources by Lao PDR. The expansion of the existing Kaolieo Treatment Plant at the first stage was selected as one of the priority projects and the capacity of Kaolieo Treatment Plant will be increased to 60,000 m3/day, after the completion of the expansion of the existing Kaolieo Treatment Plant.

The expansion of Kaolieo Treatment Plant includes work planned for the intake facilities, the treatment facilities with a chemical feeding facilities, the distribution facilities, the electrical facilities and other miscellaneous works. Figure 33-1 shows a flow diagram of the treatment process for the proposed expansion works. Details of each facility are mentioned in the following sections.

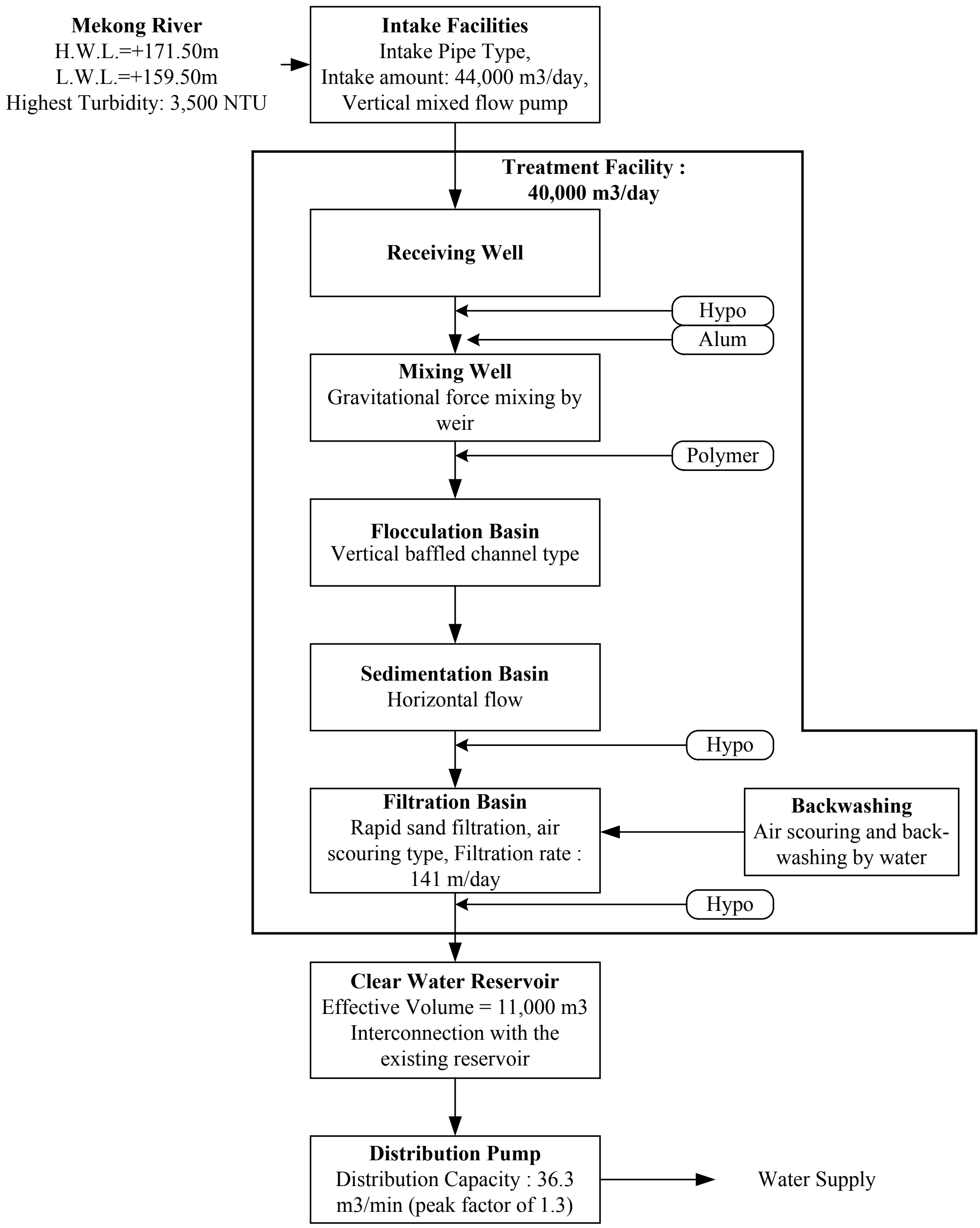
3.3.2 Intake Facilities

(1) Necessity Modifications to the Intake Facility

The existing plant with a capacity of 20,000 m3/ day has an intake facility of an intake tower type. However, the existing intake facility can not be utilised for the expansion works. Since the opening of the intake mouth of the existing intake tower is not large enough for the expanded capacity and it is very difficult to widen the existing opening, an additional intake facility for the expansion works should be considered and a study on the selection of the intake system is discussed below.

A water treatment plant ceases to function when the intake system fails to supply water. Malfunction of this system results in the interruption of the water supply to the community. The essential factors for the intake system are reliability, safety, and minimal operation and maintenance. Therefore, the intake must be located in an easily accessible location and designed and built to supply a specified quantity of best available quality of water.

Figure 33-1 Proposed Treatment Process for Extension of Kaolieo Treatment Plant



(2) Feature of Raw Water

Features of the raw water at Kaolieo Treatment Plant are;

- The maximum raw water turbidity was 3,500 NTU according to past records (2002) in the rainy season, while the turbidity was 6,800 NTU at the Chinaimo Treatment Plant according to past records (1996). The difference in raw water turbidity between the Chinaimo and Kaolieo Treatment Plants is explained by the following reasons:
    a. The Kaolieo existing intake site is a main stream of the river and a rather rapid stream even during the dry season, while the Chinaimo existing intake site is not in the main stream of the river therefore the velocity of the river flow is smaller than at the Kaolieo WTP.
    b. The Kaolieo existing intake type is an Intake Tower which is constructed in the river flow; while the Chinaimo intake type is an Intake Gate which is constructed on the river bank by excavating a part of the river bank.
    c. The Kaolieo intake can introduce surface water which contains lower turbidity by using three different levels of intake gate; while the Chinaimo intake always introduces raw water from one sluice gate at the bottom of the river.
- Suspended solids of raw water turbidity are mainly silty, fine clay.
- The maximum difference of water level between the highest and lowest levels is about 13 metres.
- The construction site is a main stream of the river and a rather rapid stream even during the dry season.
- Much floating debris such as drift wood, trees and plants flow down the river during the rainy season.
- The turbulent stream causing by the existing Intake Tower is certify the bank erosion that the bank protection of the downstream of existing Intake was constructed.
- The slope of the river bank at the construction site is steep.

(3) Selection of Intake Structure Type

An new intake facility is proposed to be constructed upstream of the existing intake facility. There are five alternative types of intake facilities, as listed below:

a. Floating Barge Type (Temporarily installed at Kaolieo)
b. Inclined River Bank Bed Type (Irrigation intake at Thangone)
c. Intake Gate Type (Chinaimo Type)
d. Intake Tower Type (Kaolieo Type)

e. Intake Pipe Type

Of these different systems, the intake pipe type is recommended as the new intake facility for the expansion of the Kaolieo Treatment Plant, for the following reasons.

1) Floating Barge Type

The floating barge type intake has an advantage against large fluctuations of water levels and is usually selected for small scale intake and slow river-flow situations. In the case of Kaolieo WTP, the scale of intake is large - more than 40,000 m3/day and the water velocity is fast even during the dry season. Furthermore, large amounts of floating debris which will damage the barge flow down the river. Therefore, the floating barge type of intake is not recommended.

2) Inclined River Bank Bed Type

The inclined river bank bed type of intake usually requires frequent maintenance on bearing parts, the sliding areas between the rotating parts and the fixed portion of the pump and motor due to the inclined alignment installation of the this moving equipment on the inclined intake structure. There is also the possibility of damage by floating debris flowing down the river. Therefore, this type is not recommended to be utilized for the project.

3) Intake Gate Type (Chinaimo Type)

The intake gate type is evaluated as not suitable for the Kaolieo WTP because the river stream will be obstructed by the stage structure of the intake which will be constructed for the purpose of removing accumulated grit/sludge at the mouth of the intake. The turbulent stream caused by this preventive structure, the stage, may cause bank erosion on the adjacent bank, that is, it will require bank protection for a wide surface area of the bank nearby.

4) Intake Tower Type (Kaolieo Type)

The intake tower type is evaluated as not suitable for the Kaolieo WTP because the turbulent stream caused by both the existing and new intakes might cause significant bank erosion, making necessary extensive bank protection work.

5) Intake Pipe Type

An advantage worthy of special mention of the intake pipe type system is that this type will not cause any effects to the river water flow. Intake pipes are pierced through the river bank at different levels and are able to introduce surface water which contains lower turbidity. Although grit/sludge sedimentation in the pipes and pump suction well, this will be solved by installation of flushing piping.

Intake Pipe Type has misgivings about sedimentation or accumulation of mud inside the intake pipe which is stopped water intake when raw water introduced through other pipe. Raw water will be introduced though the pipe which is the nearest from the river surface since surface water contains lower turbidity. Therefore, stoppage of the intake pipe will occur deeper side. At the certain depth of river, water flow will be gentler comparing with surface, and water circulation inside the stopped intake pipe will not occur. This means, that sedimentation of mud will be observed but the sedimentation will be very limited since there will be no intrusion of turbidity from the mouth of the pipe. Taking account of the characteristics of the turbidity of the Mekong River, they are very fine silt, accumulation is estimated also very limited.

In addition, the results of the cost comparison among five different types of the intake facilities, there were no significant difference in aspect of the costs of construction and equipment. The costs for the Intake Tower and Inclined River Bank Bed Types show slightly higher costs and the other three types show lower. From the reasons mentioned above, the intake pipe type is recommended to be adopted as the new intake facility at the Kaolieo WTP.

Figure 33-2 Floating Barge Type

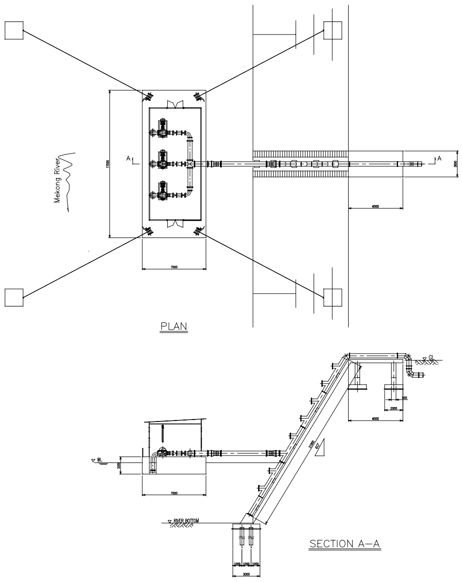


Figure 33-3 Inclined River Bank Bed Type

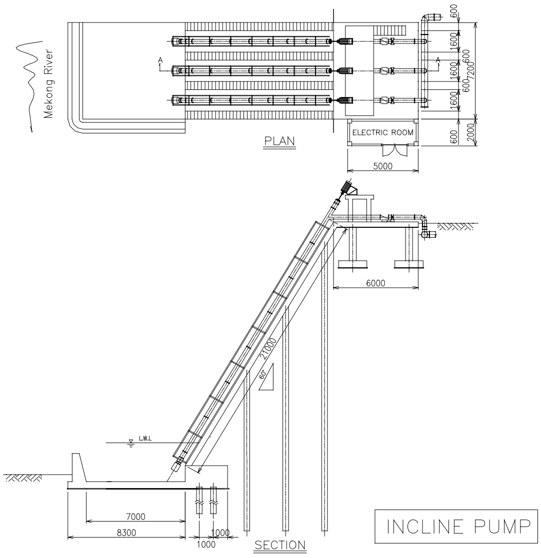


Figure 33-4 Intake Gate Type

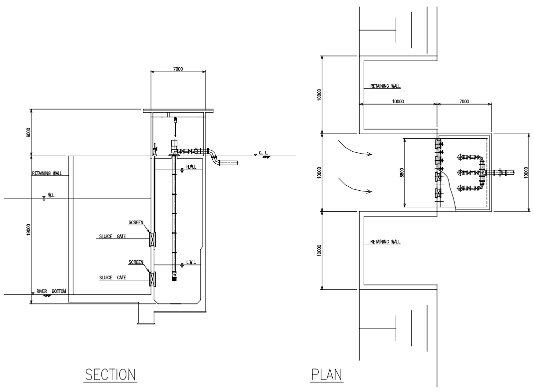


Figure 33-5 Intake Tower Type

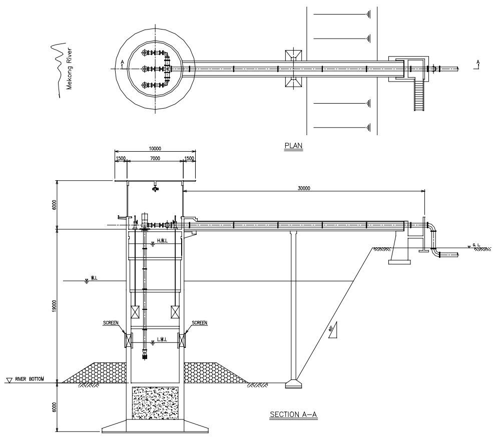
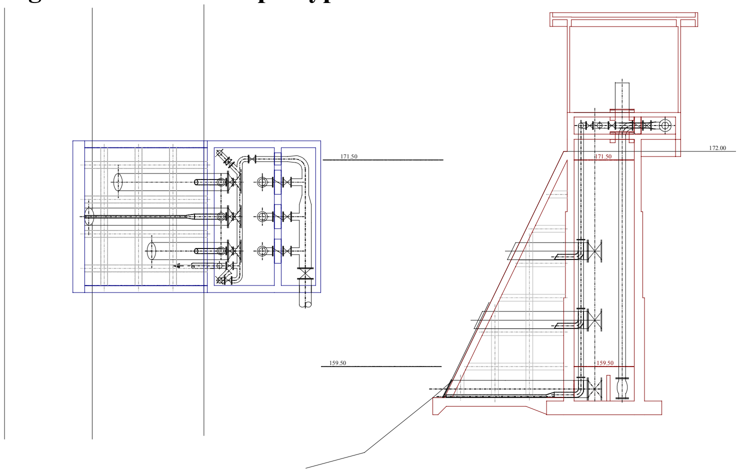


Figure 33-6 Intake Pipe Type



(4) Selection of Pump Type

Available raw water intake pump types for the intake pipe structure are:

a. Submersible Mixed Flow Pump
b. Vertical Mixed Flow Pump

The difficulty associated with using a submersible mixed flow pump is the requirement to send the pump to the pump manufacturer in situations of pump failure since the submersible pump can not be repaired by the NPVC. On the other hand, the vertical mixed flow pump can be repaired by the NPVC in case of pump failure. Table 33-1 compares these 2 types of pumps. The vertical mixed flow pump is recommended to be adopted in the Project.

A centrifugal pump is also one of the alternatives for the selection of pump type. However if a centrifugal pump was used at the intake facility, the pumps should be placed below the low water level of the Mekong River and therefore construction costs will be double compared with the other type of intake pumps. Based on the operation and maintenance costs of the existing vertical mixed flow pumps at the Chinaimo Treatment Plant for past 5 years, the additional construction cost by the centrifugal pump corresponds to about 120 years operation and maintenance costs of mixed flow pumps. Considering the operation and maintenance costs of the centrifugal pumps, this type is not recommended for the expansion works.

Table 33-1 Comparative Table of Alternative Intake Pumps

	Submersible Mixed Flow Pump	**Vertical Mixed Flow Pump**
Installation	Pumps and motors are installed under L.W.L. of pump well.	Pumps are installed under L.W.L. of pump well.
	Double floor installation type: Pump, motor, piping support on the lower floor. Space between upper and lower is utilized for piping.	Double floor installation type: Motors are installed on upper floor and pumps, pipings, pump shafts, etc. support with lower floor.
Accessories	Make-up water device is required for water seal motor.	Lubricating water pump for bearing is required.
Control and Automation	Simple operation control and easy automatic operation due to the make-up water device only.	Rather complicated operation control and automatic operation are required additional accessories.
Operation Range and Cavitation	Pump can be operated in a wider range of water flow quantity.	In the range of smaller water flow quantity, pump operation may be difficult.
	Less possibility of cavitation, since pump impeller is submerged.	Less possibility of cavitation, since pump impeller is submerged.
Noise	Little due to installation of motor in the water	Noise reduction measures will be required.
Failure Frequency and its Countermeasure	Frequency of failure is lower than the vertical mixed flow pump.	Frequency of failure is higher than the submersible mixed flow pump.
	In case of repairing for mechanical seal's leaking, the equipment should be sent to pump manufacturer.	Most repairing work can be done by the NPVC itself.
Maintenance	Hard work on routine inspection due to installation of pump in the water	Hard work on routine inspection due to installation of pump in the water
	Periodical replacement for make-up water device is required.	Periodical inspection of motor and lubricating for bearing, and periodical replacement for lubricating oil are required.
Evaluation	Frequency of failure is lower than the vertical mixed flow pump. In case of repairing for mechanical seal's leaking, the equipment should be sent to pump manufacturer.	Frequency of failure is higher than the submersible mixed flow pump. Most repairing work can be done by the NPVC itself.
	not recommendable	recommendable