National Directorate of Water and Sanitation Services
Ministry of Infrastructure
The Democratic Republic of Timor-Leste

IMPLEMENTATION REVIEW STUDY REPORT ON THE PROJECT FOR URGENT IMPROVEMENT OF WATER SUPPLY SYSTEM IN BEMOS-DILI (PHASES II) IN THE DEMOCRATIC REPUBLIC OF TIMOR-LESTE

December 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

SANYU CONSULTANTS INC.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the Implementation Review Study on the Project for Urgent Improvement of Water Supply System in Bemos-Dili (phases II) in the Democratic Republic of Timor-Leste, and organized a survey team headed by Kosuke HIROTA of Sanyu Consultants Inc. between October 13, 2010 to December 10, 2010.

The survey team held a series of discussion with officials concerned of the Government of the Democratic Republic of Timor-Leste, and conducted field investigations. As a result of further studies in Japan, the present report was finalized.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Democratic Republic of Timor-Leste for their close cooperation extended to the survey team.

December, 2010

Sigenari KOGA
Director General
Financing Facilitation and Procurement
Supervision Department
Japan International Cooperation Agency

Summary

(1) Outline of Timor-Leste

The Democratic Republic of Timor-Leste is a new country who gained independence from Indonesia on May 2002 with due support by the multinational UN forces as operated based on the resolution by UN's Security Council. Before the independence, the country experienced an independent war, merging by Indonesia in 1976 and also the rule by Portuguese for more than 400 years. The country is located at Timor Island sharing the border with Indonesia at its eastern-most edge. The national total land covers as large as 14,600 square km and formed by 13 provinces having about 1,065,000 populations (IMF estimate in 2008). The capital city of Dili is located on the northern coast facing the Sea of Flores and on the southern side there is a high mountain range of 700-1,000 m elevation in east-west direction.

The Dili Water Supply System had been severely damaged due to the conflict and disorder occurred during the independent war and totally malfunctioned. The system was urgently rehabilitated by various international aid agencies including the government of Japan and restored to have some partial functions, though the quantity served and water pressure for distribution were insufficient in most of the service areas. After the said emergency measures, it was Japan International Cooperation Agency (JICA), Japan and Asian Development Bank (ADB) who have implemented a full-scale rehabilitation/improvement projects for the existing water supply system as well as human resources development project for leveling up of management capacity for National Directorate of Water and Sanitation (DNSAS) of the Ministry of Infrastructure. The present situation is, however, that the implementing/management capability of DNSAS is still not competitive enough and there remain several problem issues to be tackled as initiating water tariff collection system, adequate rehabilitation of distribution network and etc.

(2) Background, Proceedings and Contents of Requested Project

The development plans made by the Government of Timor-Leste are Strategic Development Plan (SDP 2011-2030) as long term plan and Sector Investment Plan (SIP 2006-2010) as middle term plan and National Priorities as annual plan. In the present, SDP is under the process of approval by parliament, new SIP will be included on SDP. Therefore, National Priorities is priority plan until approval of SDP. The priority of the 2010 year development plan is "Road and Water", it mentions, target is 90 % of population will access the sustainable and safety and enough water until 2015 in consideration of Millennium Development. (At 2009, population of area provided water supply is 54 % in urban area and 46 % in rural area.)

The Dili Water Supply System being operated at present takes its raw water sources from river surface water and deep wells in the suburbs and supplies 32,000 m^3/day (May 2007) of treated water for 160,000 city residents (Approx. estimate as of March 2006). Of the said water supply system, about 57,000 people, 35% of the total population of Dili city is supplied with the treated water through having the raw water of 6,200 m^3/day taken from Bemos river and conveyed through the subject raw water main to the Dili central water treatment plant (Urgent grant aid construction project by Government of Japan (GOJ) in 2000) and Bemos water treatment plant (Rehabilitation grant aid by GOJ). The Bemos raw water main system has ever been rehabilitated as UNOPS's grant aid project (Fund provided by GOJ) under the "Dili Water Supply Rehabilitation and Improvement Project" after the facilities built during the time of Indonesian rule were found much deteriorated.

The subject raw water main, however, had been severely damaged due to the floods caused by torrential rain occurred in the years 2004 and 2005. DNSAS instantly made necessary repairs and the facilities' function itself has been recovered but the measure taken is not complete in various aspects. While, the Lower Service Reservoir and valve chamber attached to the Bemos Water Treatment Plant have been found necessary to have a proper renovation/improvement as soon as possible due to the concrete structures' deterioration and resultant water leakage as those had been built during 1980's. In case if in future the raw water main may break down or the deteriorated service reservoir may collapse, it is expected that the water supply function will not work and it may cause worsening conditions for the city people in terms of the sanitary situation and access to the safe water due to the suspension of water supply for a long period.

With having the background situation as said the government of Timor-Leste has made a request on January 2006 to the government of Japan to implement a rehabilitation/improvement on the core water supply system in Bemos-Dili with a disaster prevention viewpoint, so that the required raw water can be supplied to the water treatment plants on sustainable basis even if floods may re-occur in future. In response to the request, a primary design study on the Project for Urgent Improvement of Water Supply System in Bemos-Dili had carried out by JICA on 2007. After confirmation of importance and urgency and relevant on the project, the basic design study was carried out on 2008, and then Japan Grant Aid Project started from 2009 (hereinafter referred to as "the Phase I Project").

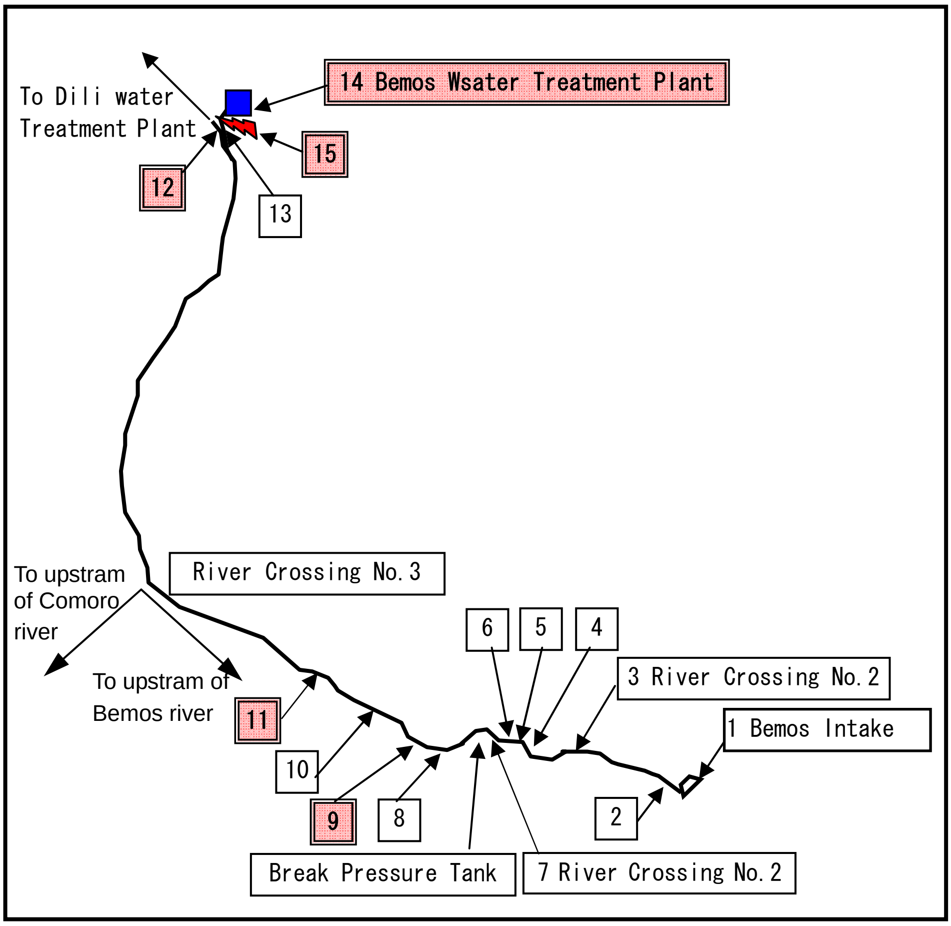
Concerning the Phase I Project, Exchange of Notes between the Government of Timor-Leste and the Government of Japan (hereinafter referred to as "the E/N"), and Grant Agreement between the Government of Timor-Leste and JICA (hereinafter referred to as "the G/A") were signed on the 26th day of May, 2009. After signing the construction contract in January 2010, however unusual rainfall and floods occurred in March, April and May in the area of upstream of Bemos River. Floods caused further damages to existing pipeline and facilities, furthermore extending the erosion and change of existing ground condition at the river bank. There were six (6) sites damaged of fourteen (14) sites targeted for the Phase I Project. Therefore, it was necessary to modify the design regarding the structures of six (6) damaged sits. Moreover, the landslide had been occurred at access road to Bemos water treatment plant, it is difficult to pass by car until now. Therefore, it is necessary to take countermeasure for landslide.

The project cost, which is considered proposed design modifications and countermeasure for landslide, is over the E/N amount. Therefore, it had to exclude the some structures from the Phase I Project, the structures, which are important and urgency for the rehabilitation at upstream of Bemos

River, was selected in the Present Project. However, the structures exclude from the Phase I Project and a new additional structure (Countermeasure for landslide at Bemos Water Treatment Plant) is necessary for successful urgent improvement of water supply system. Therefore, Government of Timor-Lest requested Japan Grant Aid regarding the Project for Urgent Improvement of Water Supply System in Bemos-Dili Phase II (hereinafter referred to as "the Phase II Project"). The main component of the Project is as follows:

Target Component of Phase I Project and Phase II Project

Original components		Phase	
		I	II
Structure No.1	Renovation of Bemos Intake	○	
Structure No.2	Construction of Inlet and Grit Chamber	○	
Structure No.3	Renovation of River Crossing No.1	○	
Structure No.4	Construction of Aqueduct and Flow Path of Tributary	○	
Structure No.5	Protection of Pipeline at Upstream Existing Retaining Wall	○	
Structure No.6	Construction of Revetment at Right Bank River Terrace	○	
Structure No.7	Renovation of River Crossing No.2	○	
Structure No.8	Protection of Pipeline at Downstream Existing Retaining Wall	○	
Structure No.9	Protection of Pipeline by Revetment at Left Bank Terrace No.1		●
Structure No.10	Improvement of Exposed Pipeline by Rerouting under Riverbed	○	
Structure No.11	Protection of Pipeline by Revetment at Left Bank Terrace No.2		●
Structure No.12	Construction of Pipe Protection and Concrete Pavement at Comoro Right Bank		●
Structure No.13	Installation of Valves and Wash-outs	○	
Structure No.14	Renovation of Lower Service Reservoir and Valve Chamber at Bemos Water Treatment Plant		●
New Component			
Structure No.15	Counter-measure for land slides at the access road to Bemos water treatment plant		●



No.9, 11, 12, 14, 15 is target of Phase II Project

Note) No.1 – 14 are original components of Phase I project

Location of the each component

(3) Outline of Study Result and Project Components

JICA decided to carry out the Implementation Review Study on the Phase II Project, and dispatched the study team to the project site during the period from October 16 to October 24, 2010. The study team had a series of discussion/consultation meetings with DNSAS, the project executing body of the government of Timor-Leste, and other related agencies and also carried out field surveys.

In the Phase I Project, it was planed to rehabilitate the Bemos Intake and the part of the pipeline from Bemos Intake to Bemos Water Treatment Plant and lower service reservoir of Bemos Water Treatment, because the project contribute to achievement of stable water supply in Dili, which is purpose of water sector under the national development plan. Regarding the components that were excluded from the Phases I Project, the original plan was adopted based on the present condition and OM condition.

Regarding the countermeasure for landslide, stability analysis was carried out based on the result of geological survey and soil test, according to the result it is planed to remove the landslide soil and replace to good permeability material such as river sand gravel, and to construct concrete retaining wall and protection for stopping the slope collapse. The construction plan was made in consideration for the point that the work need to finish before hard rainy season and the work is to secure the access road to Bemos Water Treatment Plant for rehabilitation of Lower service reservoir at the same time.

Contents of Project Works

Work items	Length	Rehabilitation / Improvement manner
1 Structure No.9 Left bank terrace of Bemos river	50 m.	• Protection of existing pipeline by revetment and re-filling by sand and gravel
2 StructureNo.11 Mountain foot slope of left bank of Bemos river	179 m.	(Pipeline exposed section as per design, but many rock fall and strike the pipeline, so that) • Shifting of pipeline route and embedding
3 Structure No.12 Comoro river right bank Steep slope road section	100 m.	• Construction of dual purpose road and drain (concrete pavement with wheel guard) • Construction of road side protection works including pipe supports
4 Structure No.14 The Lower Service Reservoir & valve chamber of Bemos water treatment Plant	-	• Renovate the facilities to have the equal capacity and function with the existing ones
5 Structure No.15 Counter-measure for land slides at the access road to Bemos water treatment plant	-	• Construction of L-shaped retaining wall • Slope protection

(4) Project Implementation Schedule and Cost Estimation

For the implementation of the subject project, it will take 7.5 months for detailed design and 10.5 months for construction. The portion of the project cost to be born by the government of Timor-Leste is estimated at about 2 million Japanese Yen.

(5) Project Evaluation

1) Relevance of the Project

The Phase I & II project purpose is to secure safety and sustainable water supply to zone 3 and 4 of water supply service area in Dili, target beneficiaries of the project are 5.7 million peoples (at 2006), which is 35 % of the population of Dili, and also contribute to the improvement of BHN in Timor-Leste. Improvement of water supply facilities will bring improved people's lives. It is important to improve the water supply condition in order to stabilize people's livelihood considering that riots have occurred in the past in Dili.

Bemos River, which flows near the target sit of the Project, is steep stream and flood occurred in every rainy season gives the big damage to the water facilities near the river, therefore, it is necessary to rehabilitate the damaged facilities as soon as possible. Lower service reservoir in Bemos water treatment plant has deteriorated, it is possible to collapse in case of no rehabilitation, it is required to rehabilitate soon. Countermeasure for landslide is also necessary in order to secure the only access road to Bemos Water Treatment Plant.

Intake and pipeline, which will be rehabilitated in the Project, is adapted to gravity flow system. Periodical sediment works become easy by improvement of intake and adding the wash out facilities. It is possible to maintain the facilities by present staff and present budget of DNSAS. Water delivery system of the water treatment plant after the rehabilitation of lower service reservoir is same as present condition, daily peroration and maintenance of the fasciitis can be done by present staff. The high technology and special equipments will not be used in the Project.

In Timor-Leste, one of the priority targets of national development plan is to improve the nation health, its strategy is to become that 80 % of urban people can access the safety water during 24 hours. The project contributes to achieve the above purpose.

Therefore, it is relevant to carry out project by Japan grant aid.

2) Effectiveness of the Project

(a) Quantitative effect

It is possible to supply water continuously without damaged by flood after rehabilitation. Water supply volume will increase and it is possible to reduce the stop of the water supply, because maintenance becomes easy after installation of wash out facilities and grid chamber.

Index of Quantitative effectiveness

Index	Reference on 2009	Target on 2013
Supply water volume	7,800 m^3/day	8,800 m^3/day
Number of day to stop water supply per year	7 days	0 days

(b) Qualitative effect

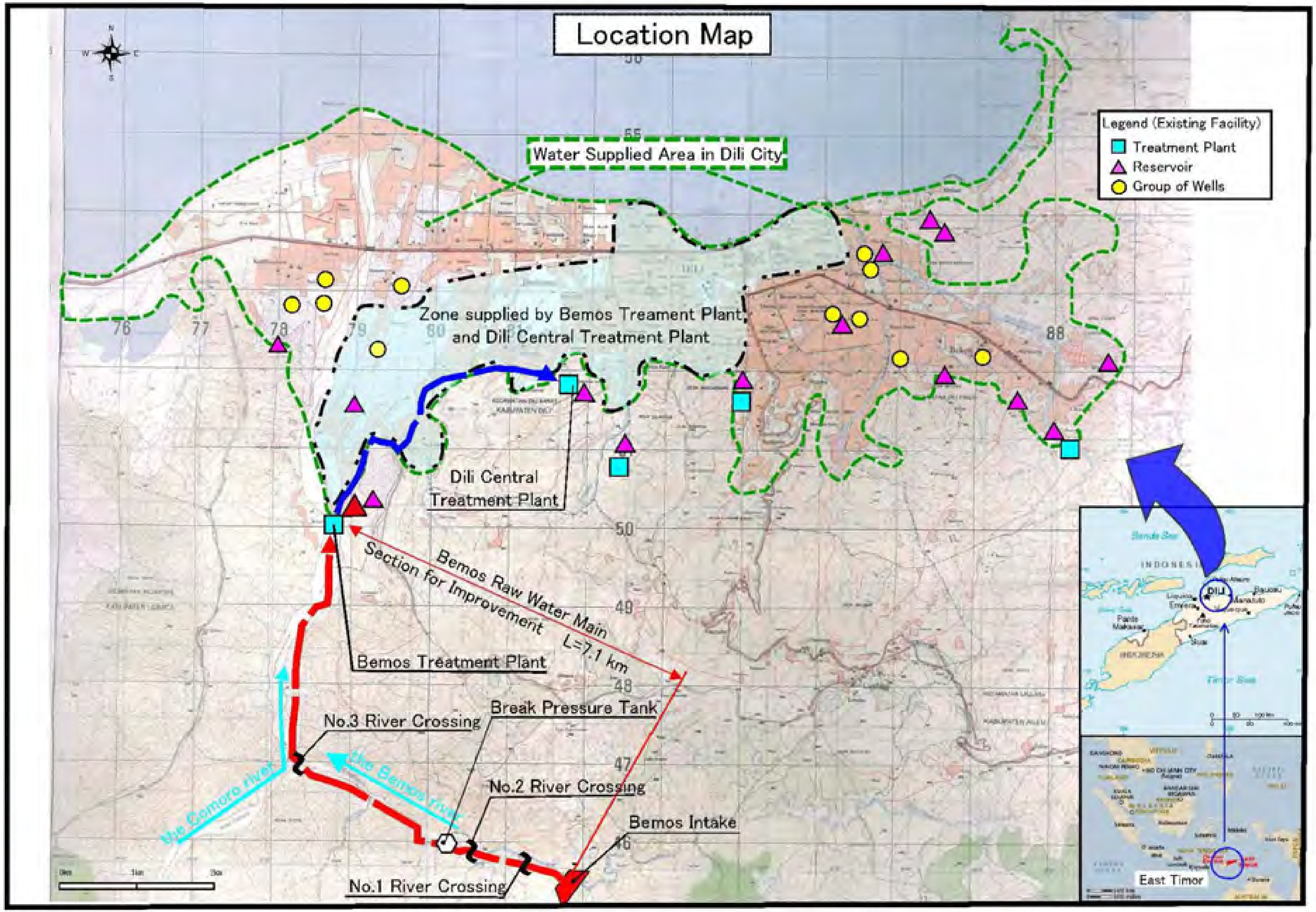
The qualitative effects are as follows

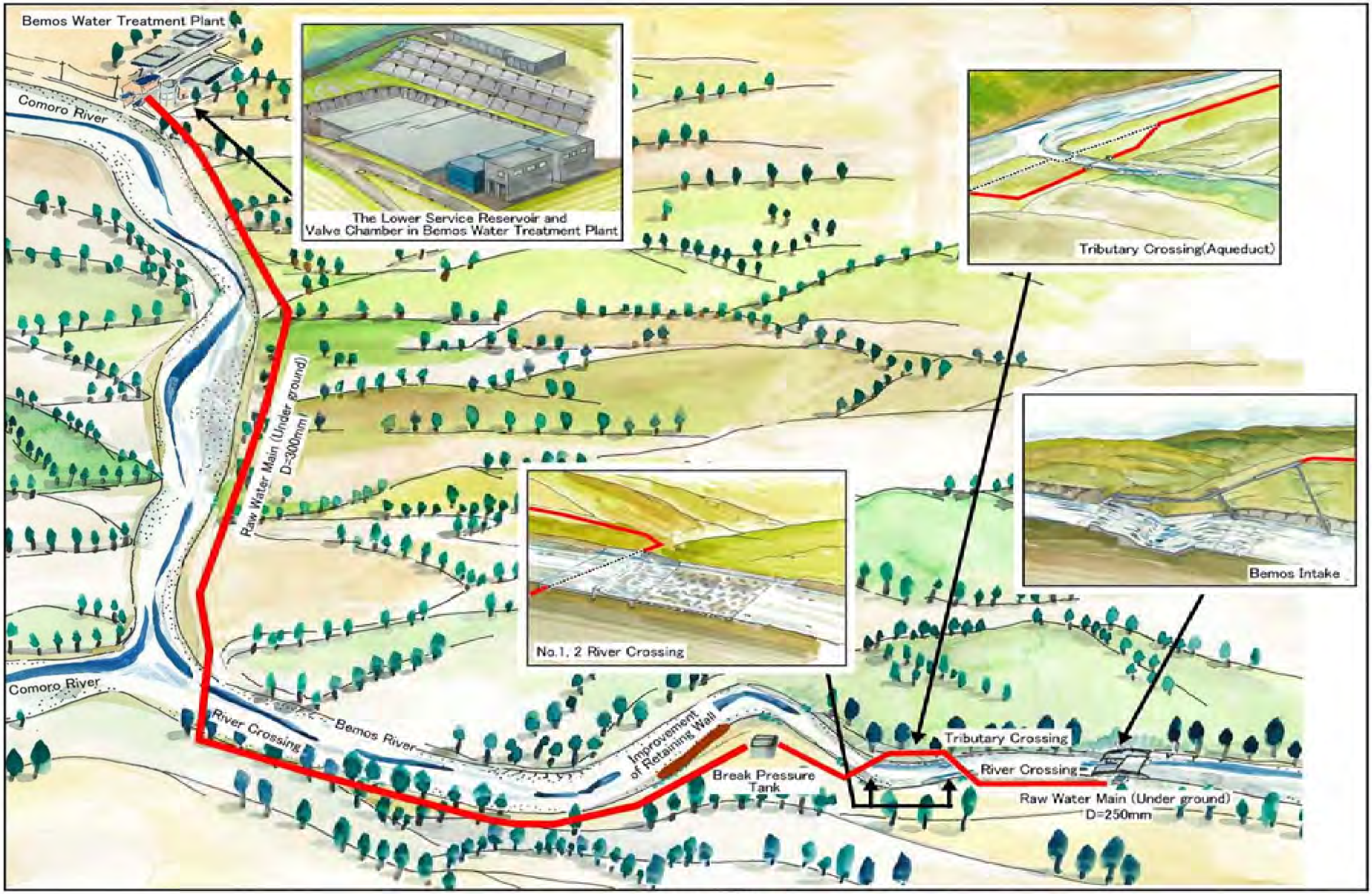
- After rehabilitation of the water supply system, the supply for raw water to water treatment plant will be stabilized therefore it contributes to improve the water supply and sanitation in Dili.
- By stabilization of raw water supply, it is possible to operate water supply facilities and to supply water deliberately, it contribute to establish water fee collection system.

As mentioned previously, the project contributes to improve sanitation and public health in Dili. Therefore, it is relevant to carry out project by Japan grant aid. It is possible to operate and maintain the facilities by DNSAS after the rehabilitation, because of enough budget and staff. Thus, it is judged the implementation of Project is high relevant and effective.

Contents

[Appendices]


Location Map
Water Supplied Area in Dili City
Legend (Existing Facility)
Treatment Plant
Reservoir
Group of Wells
Zone supplied by Bemos Treament Plant and Dili Central Treatment Plant
Dili Central Treatment Plant
Bemos Raw Water Main Section for Improvement L=7.1 km
Bemos Treatment Plant
Break Pressure Tank
No.3 River Crossing
No.2 River Crossing
Bemos Intake
No.1 River Crossing
the Bemos river
the Comoro river
East Timor
INDONESIA
DILI



Perspective

The Project for Urgent Improvement of Water Supply System in Bemos-Dili

Picture of site condition

Structure No.11 Mountain foot slope of left bank of Bemos River

Pipeline was setting on the ground in this section, there is many falling rock around pipeline, and some big stone were shown on the pipe.

Structure No.12 Comoro river right bank Steep slope road section

In rainy season the heavy rain erode the no pavement road and the pipe was exposed. The car pass on the pipe and road will be eroded, so it is possible to break the pipe.

Structure No.14 The Lower Service Reservoir & valve chamber of Bemos water treatment Plant

Reservoir was deteriorated, there are widely concrete peeled on the roof, the roof would be fallen. There are repair portion and crack on the inside wall, there are leakage on outside wall.

Structure No.15 Land slides at the access road to Bemos water treatment plant

The landslide occurred at slope beside the access road to Bemos Water treatment Plant, covered on the road. Landslide soil was sludge with much water just after landslide, dried for dry season. But wet condition in soil, the soil becomes soft again by rain water.

LIST OF FIGURES & TABLES

List of Figures

List of Tables

ABBREVIATIONS

Abbreviations

AAP	Annual Action Plan
ADB	Asian Development Bank
AusAID	Australian Agency for International Development
CFET	Consolidated Fund for East Timor
CIDA	Canadian International Development Agency
CEP	Community Empowerment and Local Governance Project
CWSSP	Community Water Supply & Sanitation Project
DNSAS	National Directorate of Water and Sanitation
ECHO	European Commission Humanitarian Aid department
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GOJ	Government of Japan
GTZ	Geutsche Gesellschaft fur Technische Zusammenarbeit
ICRC	International Committee of the Red Cross
IDP	Internally Displased People
IEE	Initial Environmental Examinations
JICA	Japan International Cooperation Agency
MOED	Ministry of Economy and Development
MOI	Ministry of Infrastructure
MPF	Ministry of Planning and Finance
MTCPW	Ministry of Transport, Communications and Public Works
NDES	National Directorate for Environmental Service
NDP	National Development Plan
NGO	Nongovernmental Organization
O/M	Operation and Maintenance
SIP	Sector Investment Program
SSECTOPD	Secretary of State for Environmental Coordination, Territorial Ordering and Physical Development
TA	Technical Assistance
TFET	Trust Fund for East Timor
UN	United Nations
UNICEF	United Nations Children's Fund
UNDP	United Nations Development Programme
UNOPS	United Nations Offices of Project Services
UNTAET	United Nations Transitional Administration in East Timor
USAID	United States Agency for International Development

Glossary

mm	millimeter	sec	second
cm	centimeter	min	minute
m	meter	hr	hour
km	kilometer	m/sec	meter per second
cm^2	square centimeter	m^3/sec	cubic meter per second
km^2	square kilometer	kg	kilogram (=1,000 g)
m^3	cubic meter	kgf	kilogram force
t	ton (1,000 kg)	tf	ton force
N	newton	kN	kilonewton
P	pascal	%	percent
Lpcd	liter per Capita per Day		

Currency

Japanese Yen (J. Yen)
US Dollar (US$)

Exchange rate (September 2010)

US$ = J.Yen 89.91

Chapter 1 Background of the Project

Chapter 1 Background of the Project

1-1 Background of the Project

The Dili Water Supply System being operated at present takes its raw water sources from river surface water and deep wells in the suburbs and supplies the treated water for 160,000 city residents. The total volume of water distributed is estimated at 32,000 m^3/day (As of the survey conducted on May 2007). The subject Bemos Raw Water Main, one of the major facilities under the overall water supply system, was constructed in 1984 during the time of Indonesian rule.

The raw water main being deteriorated after decades has been rehabilitated (2000-2003) under the “Dili Water Supply Rehabilitation and Improvement Project” as UNOPS’s urgent grant aid project (Fund provided by the Government of Japan). The same raw water main is one of the core facilities in the overall system as it supplies as much as 6,200 m^3/day, about 20-30% of the total volume for about 57,000 people (35% of city residents).

The subject raw water main, however, had been severely damaged due to the floods caused by torrential rains occurred in the years 2004 and 2005. DNSAS instantly made necessary repairs and the facility’s function itself has been recovered but the measure taken is not complete in various aspects. Accordingly, it was afraid that if in case there happened to be further flood damages on the raw water main facilities and also collapse of lower reservoir in Bemos water treatment plant, in future it may cause long suspension of water supply.

In view of the foregoing, the Government of Timor-Leste made a request, on January 2006, for the project aiming at maintaining the function of stable raw water supply to Dili water supply system through adequate rehabilitation / improvement of the Bemos raw water main from the disaster prevention viewpoint. In 2007, the preliminary survey had been carried out, importance and urgency and validity of request was confirmed, and then the Basic design study was carried out in 2008. In present (on October, 2010), “the Project for urgent Improvement of Water Supply System in Bemos-Dili” (hereinafter referred to as “the Present Project”) is under implementation.

Concerning the Present Project, Exchange of Notes between the Government of Timor-Leste and the Government of Japan (hereinafter referred to as “the E/N”), and Grant Agreement between the Government of Timor-Leste and JICA (hereinafter referred to as “the G/A”) were signed on the 26th day of May, 2009.

After signing the construction contract in January 2010, however unusual rainfall and floods occurred in March and April in the area of upstream of Bemos River. Floods caused further damages to existing pipeline and facilities, furthermore extending the erosion and change of existing ground condition at the river bank. There were six (6) sites damaged of fourteen (14) sites targeted for the Present Project.

Therefore, it was necessary to modify the design regarding the structures of six (6) damaged sits. Moreover, the landslide had been occurred at access road to Bemos water treatment plant, it is difficult to pass by car until now. Therefore, it is necessary to take countermeasure for landslide.

The project cost, which is considered proposed design modifications and countermeasure for landslide, is over the E/N amount. Therefore, it had to exclude the some structures from the Present Project, the structures, which are important and urgency for the rehabilitation at upstream of Bemos River, was selected in the Present Project.

However, the structures exclude from the Present Project and a new additional structure (Countermeasure for landslide at Bemos Water Treatment Plant) is necessary for successful urgent improvement of water supply system. Therefore, Government of Timor-Lest requested Japan Grant Aid regarding the Project for Urgent Improvement of Water Supply System in Bemos-Dili Phase II (hereinafter referred to as "the Phase II Project"). The main component of the Project is as follows:

Table 1-1.1 Target Component of Phase I Project and Phase II Project

Original components		Phase I	Phase II
Structure No.1	Renovation of Bemos Intake	○	
Structure No.2	Construction of Inlet and Grit Chamber	○	
Structure No.3	Renovation of River Crossing No.1	○	
Structure No.4	Construction of Aqueduct and Flow Path of Tributary	○	
Structure No.5	Protection of Pipeline at Upstream Existing Retaining Wall	○	
Structure No.6	Construction of Revetment at Right Bank River Terrace	○	
Structure No.7	Renovation of River Crossing No.2	○	
Structure No.8	Protection of Pipeline at Downstream Existing Retaining Wall	○	
Structure No.9	Protection of Pipeline by Revetment at Left Bank Terrace No.1		●
Structure No.10	Improvement of Exposed Pipeline by Rerouting under Riverbed	○	
Structure No.11	Protection of Pipeline by Revetment at Left Bank Terrace No.2		●
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Structure No.14	Renovation of Lower Service Reservoir and Valve Chamber at Bemos Water Treatment Plant		●
New Component			
Structure No.15	Counter-measure for land slides at the access road to Bemos water treatment plant		●

1-2 Natural Conditions

(1) Meteorology, Hydrology and Water Quality

(a) Climate

The climate of Timor-Leste is of the tropical monsoon type where rainy season and dry season are clearly demarcated. During the period from December to March, the seasonal humid wind in north-west direction is predominant and it brings about thunderstorms and downpours all over the country to enter into the rainy season. In January there happens to have strong winds and causes some damages on the houses and it was in January 1993 that the strong wind blows (Cyclone) caused serious damages on more than 400 houses. While the period from May to October, the dry trade wind in south-east direction from Australian continent is superior and the whole country enters into the dry season except the coastal area and south side mountain range slopes where rain continues until July every year. In Timor-Leste, the dry season periods are different from place to place with having only 2-3 months in some places and as long as 10-11 months in the others, but in Comoro river basin, the project site, the dry season covers about 5-6 months period and the duration available for construction works is rather limited.

(b) Temperature

The temperature in Dili city in terms of monthly mean is in the range of 27-29 degree centigrade as an example in the year of 2004, while that of the monthly maximum and minimum are in the range of 30-33 and 23-26, respectively. However, the project site is located at the low latitude region and sunshine is very strong causing as high as 40 degree at a sunny place, and adequate temperature control is necessary in mass concrete placing like intake and other major structures.

Table 1-2.1 Temperature in Dili, Mean Monthly, Max. Monthly and Min. Monthly (Unit:℃)

Month	1	2	3	4	5	6	7	8	9	10	11	12
Monthly Mean	29.0	28.3	28.1	28.7	28.3	27.4	27.2	27.3	28.7	29.3	28.4	28.4
Monthly Maximum	32.5	31.5	31.8	32.7	32.2	31.8	31.9	29.9	32.1	32.8	31.7	32.5
Monthly Minimum	25.5	25.0	24.4	24.6	24.3	23.0	22.5	24.7	25.2	25.8	25.0	24.3

(c) Rainfall

Table 1-2.2 Monthly Rainfall in Dili (unit: mm)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
Average from the year 1953 to 1999	156	125	147	115	74	43	22	17	15	26	70	138	940
Year of 2004	38	518	181	85	156	11	16	0	0	28	23	135	1,191

The annual rainfall in Timor-Leste varies much from 500 mm only to 2,000 mm. The difference is considerable as influenced by the geological features and elevations. In and around Dili city area, the annual rainfall is more or less 1,000 mm as shown in the Table 1-2.2. For the comparison purpose, the rainfall data on February 2004 when the subject raw water main was severely damaged due to the torrential rain and the resultant floods is shown in the same table.

(d) Water quality

As the result of water quality measurement done at the intake site of Bemos river, it can be said that there is no sign of water pollution by waste water from upstream basin. The measurement included the four items as indicated in the following table.

Table 1-2.3 Results of Water Quality Measurement at Bemos River Intake

Water Temperature	Electric Conductivity	pH	Coliform group count
16.0℃	114μS/cm	7.8	3/mg

The drainage conditions at the upstream basin of the intake are as noted below. In the upstream basin of the Bemos river intake where is the water source of the river, no any substantial polluting elements are found except the excreting by birds and beasts in the valleys.

1) Villages

On the mountain ridges surrounding the water source basin at the upstream of Bemos intake, there is a trunk road linking Dili with Aileu province located down-south and there exist several villages with 100-500 population along the road. The valleys in the water source basin are of very steep slope and houses and farm lands are sporadically spread over on the northern side slope where enjoys longer sunshine hours, but the numbers are rather limited.

2) Drainage of Waste Water

Along the roads, a small scale water supply system with about 25 mm dia. pipe is provided under the projects implemented by NGOs such as World Vision and Plan-Timor Leste and the village people obtain domestic water from the water tank installed for each village. Waste water from villages is mainly by washing and bathing and drainage is emptied to the natural streams in the village. The draining quantity is rather small and it is percolated into grounds naturally. Due to the excreting in outdoor most of the houses are not provided with toilet and no intrusion of accumulated night soil into the upstream basin of Bemos river is observed.

3) Drainage of Waste Water from Farming and Livestock

In the villages along the valleys in the water source basin of Bemos river, farmers cultivate coffee and it is banana and cassava in the sloping land in the mid-stream area, but without irrigation and drainage facilities there is no draining of agricultural waste water intruding into the water source basin. Many farmers engage in pig farming but mostly by pasturing, and there is no substantial quantity of waste water draining from the pig farms.

4) Fishery

As per the interview survey at Suco Tohumeta (Tohumeta village) located at the upper left bank of Bemos river, in the upstream of Bemos intake no fishing activities are observed indicating that there is no any chances of severe water pollution by fishing activities. In the mid-stream basin, fishing for ikan tuna (Similar to eel) is confirmed.

(2) Geography, Geology and Foundation Condition etc.

(a) Geography

Dili city is located at the northern coastal area of Timor island facing the Sea of Flores and on the back there is a high mountain range of elevation 700-1,000 m class in east-west direction. The slopes of the mountain towards the city are found to be mostly in bald condition due to tree cutting for firewood collection and only in rainy season some grasses are found as poor vegetation. On the western part of the city, there is Comoro river (Catchment area of 212 square km) originated from Aileu province and through the city emptying into the Sea of Flores. The river basin covers quite a large variation in terms of the elevations ranging from 0 m at the river mouth and 1,410 m at the dividing peak on the western edge of the basin. The divide on the southern peak is 1,000-1,300 m and the same on the north at the back of Dili city is 700-800 m.

Bemos river, one of the important water sources for the Dili water supply system, is a branch of Comoro river on its right bank sub-basin with having the catchment area of 43.9 square km. This sub-basin situates at the back of the mountain range at the rear of the city, the river course extends along the said mountain range to the west and finally joins with Comoro river. In the sub-basin, generally the northern slope (Right bank side) is of very steep slope with quite dense vegetation, and no substantial land reclamation has been done to date. While on the southern slope (Left bank), the slope is steep but gentler than right bank and there found some houses and banana plantation reclaimed at around the ridges. To this end, it is noted that the upstream basin of Bemos river supplies very important surface water source for the Dili water supply system and it is necessary to conserve the subject basin as a water source forest. In this concern, it is also noted that JICA has ever implemented “The Study on Community-based Integrated Watershed Management in Laclo and Comoro River Basins in the Democratic Republic of Timor-Leste” including the said sub-basin during the period of 2005-2008.

(b) Geological Features

Geologically, the island of Timor belongs to the Australian continental shelf which is formed by piling of limestone as the basement rock. The island is shaped with a high mountain range of 1,000-2,000 elevation formed by rocks. The varieties of rocks include in general metamorphic rocks of Palaeozoic era to Cenozoic era, limestones and fine sedimentary rocks of Cenozoic era, sedimentary rocks and limestone of Mesozoic and sedimentary rocks and upheaval coral reef limestone of Mesozoic. Though the island is in activity belt, there is no much igneous rocks except the comparatively new igneous rocks on Atauro island. Generally there are in the island distributions of massive limestone, calcareous mudstones and other calcareous rock of Marle.

As for the Comoro river basin, the geological feature is classified into two, one Aileu layer and the other Ainaro layer, and as shown in Table 1-2.4 the Aileu layer shares the most of the basin area. Both the right and left banks of Bemos river is of steep slope valleys and there found outcrops of phyllite and slate on the river terraces and a number of massive rocks on the river bed. Massive rocks on the river bed are derived either by rolling stones from the upstream reach or river bed rocks being exposed by scouring and erosion by flooding, both co-existing. As is the case, it is assumed that there would be such massive rocks in the river terraces on both banks of the river too. Therefore, it is necessary to reflect the necessity of demolition of such massive rocks in construction planning as well as in cost estimation if undertaking the excavation works at the river bed and terraces.

Table 1-2.4 Geological Feature in Comoro River Basin

Stratum	Era	Rock type	Area (ha)	Ratio
Alieu layer	Permian	Phyllite, Schist, Slate, Amphibolite, igneous	19,668	97.3%
Ainaro layer	Pleistocene	Conglomerate, sand, clay	544	2.7%

(c) Soil

Generally the soil layer in Comoro river basin is very thin with low water holding capacity. On the western part of the basin, higher organic content is observed as covered with thicker shade-gray color soil, while the rest is mostly of blue soil with low cation content. Depth of soil layer is closely related with the vegetation condition there and such trees with the height of more than 10 m require the effective soil depth at more than 1 m. In the thin forest and poorly vegetated area which can be seen generally on the peak, ridges and steep slope lands, laterite of red color with low fertility is predominant. In case if using the excavated soil material for embedding the raw water main pipeline, such organic materials as plant root and humus are necessary to be removed.

(d) Foundation Condition

At the Bemos water treatment plant site, the outcrop of gneiss is found. The Lower Service Reservoir is located at the depressed land as reclaimed after excavating the original ground and geologically formed by rocks and conglomerate clay. There is no sign of subsidence of the base of the Lower Service Reservoir which was constructed in 1980's, being assumed that the foundation has enough bearing capacity for the structure with the scale similar to the presently existing one.

(e) Earthquake

In the region stretching from Myanmar, through the greater Sunda islands and small Sunda islands and to the island of Timor, there is the Sunda Trench (Java Trench) where the India-Australian plate meets with the Eurasian plate. In the area in and around the trench, there occur frequent earthquakes, one of the most in the world, and large scale earthquakes have been repeated with the frequency of once in 100-150 years.

Timor-Leste is located at the eastern edge of the Sunda Trench and several large scale earthquakes have ever occurred in the past. Records of earthquake occurrence in the region including

Indonesia are shown in the Table 1-2.5 below. Judging from the records, it can be expected that similar scale earthquake may occur in the future and it is recommended to apply the same condition of design seismic co-efficient as applied in Japan for the structures to be designed under the project.

Table 1-2.5 Earthquake Records in and around Timor-Leste (Including Indonesia)

Date and year	Locations	Magnitude	Remarks
1938	Banda sea, Indonesia	8.5	-
1992	Flores isl. Indonesia	7.5	Tsunami, 2,500 dead
1996 Feb. 17	Biaku isl. Indonesia	8.2	150 dead or missing
2004 Nov. 12	Aroru isl. Indonesia	7.4	27 dead 235 injured
2008 Jan. 30	299 km N-E of Dili	6.6	Tsunami warning
2008 Apr. 19	85 km Dili, Banda sea	6.0	11.7 km Hypocenter D
2008 Jun. 6	Banda sea	6.0	122.1 km Hypo. Depth

(f) Landslide at Access Road to Bemos Water Treatment Plant

The geological map based on distribution of bare rock round landslide is shown as figure 1-2.1. In order to confirm the depth of landslide soil and soil conditions, Mackintosh penetration test and soil test has been carried out. Soil test are density of soil, moisture ratio, grain size analysis for confirmation of soil condition and nesecesary data of stability analysis.

Table 1-2.6 Summary on Result of Mackintosh Probe Test

Point	On landslide soil									Slope above landslide		
Depth (GL. -m)	No. 1	No. 1’	No. 2	No. 2’	No. 3	No. 3’	No. 6	No. 7	No. 8	No. 4	No. 5	No. 9
0.3	4	12	7	4	3	10	3	9	2	7	30	9
0.6	>30	11	13	5	6	6	8	9	3	>30	17	29
0.9	>30	7	>30	4	3	9	6	3	16	>30	>30	>30
1.2	>30	13	28	8	18	4	6	3	>30	>30		>30
1.5	12	9	15	9	15	3	8	22	>30	>30		>30
1.8	25	12	>30	>30	7	4	7	12	>30	>30		
2.1	>30	>30	>30	>30	4	27	8	8	>30	>30		
2.4	18	>30	>30		7	30	11	15	>30			
2.7	>30	17	>30		>30	29	>30	12				
3.0	>30	14	>30		>30	19	>30	14				
3.3	26	16	>30			>30	>30	16				
3.6	>30	>30	>30			>30		>30				
3.9		>30						>30				
4.2		>30										
4.5												
ave.	17	12	16	6	8	14	7	11	7	7	24	19
	11									17		
	ave, N<20	9								-		

表 1-2.7 Summary on Result of Soil Test

Item / Sample No.	Sampling point		Soil test							wet unit weight	dry unit weight	saturated unit weight
	Depth (m)	Location	Densty of soil	Moisture ratio	Grain size				Porosity			
					Gravel	Sand	Silt	Cray				
			(g/cm^3)	(%)	(%)	(%)	(%)	(%)		(g/cm^3)	(g/cm^3)	(g/cm^3)
No. 1	0.15	slipped slope	2.494	16.4	44	22	34		0.304	1.978	1.913	2.146
No. 2	0.15	Landslide	2.534	16.5	23	29	48		0.385	1.939	1.829	2.107
No. 3	0.15	Above landslide	2.571	9.4	63	15	22		0.493	1.884	1.722	2.052
Average . (all)			2.533	14.1	–	–	–		0.394	1.934	1.821	2.102
Average (No. 1, No. 2)			2.514	16.5	–	–	–		0.345	1.959	1.871	2.127

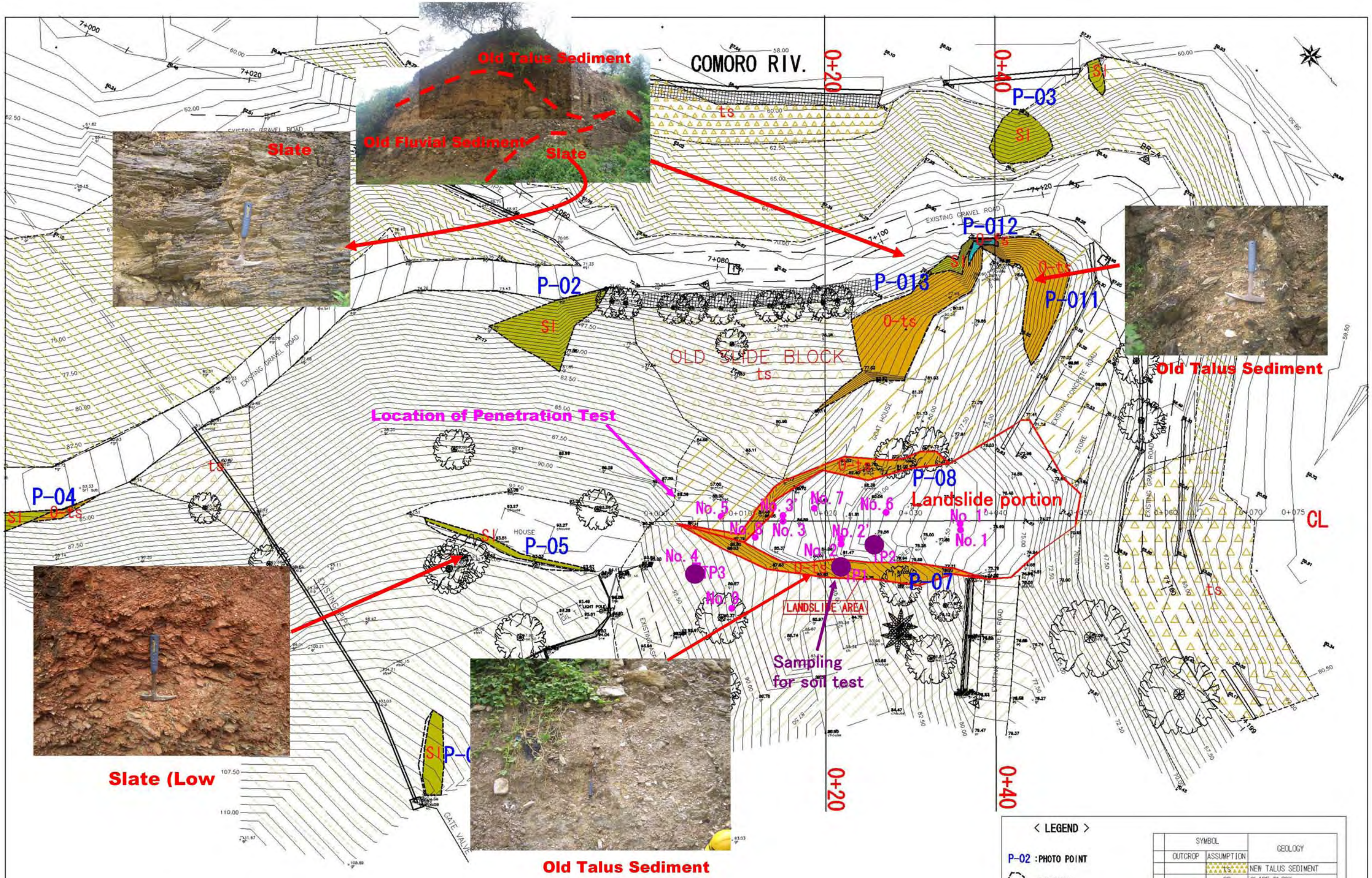


Figure 1-2.1 Geological Condition Map

1-3 Environmental and Social Consideration

In Timor-Leste, Legal system on Environmental and Social Consideration comes under the jurisdictions of National Directorate for Environmental Services (NDES), Ministry of Economy and Development. It is stipulated in Guideline #1, Environmental Requirements for Development Proposal that NDES categorize each application of development plan submitted by developer (or project implementation authority). Development plan classified as Category A requires the procedure of EIA (Environmental Impact Assessment) prior to the project implementation. Likewise, Category B needs submission of an EMP (environmental management plan). Both EIA and EMP are not necessary for the project of Category C that the serious environmental and social impact is not expected during construction and after completion of the project.

Works of the Present Project are partial improvement on the existing pipeline of raw water main, 7.1km in length and reconstruction work of the existing service reservoir with an adjacent valve chamber in Bemos treatment plant. Little or no negative impact against neither environment nor society was expected through the Present project and particular mitigation measures were also not necessary. Therefore, NDES notified DNSAS of the categorization of this project as Category C on July 11th, 2008. Above permission issued by NDES is validity for one (1) year and it is necessary to extend in every year. In 2010, the extension of permission including the Phases II Project had been completed.

The following tables show the environmental evaluation through the implementation of the project. (A: Serious impact is expected. B: Some impact is expected. C: Negligible or no impact is expected.)

Table 1-3.1 Environmental Evaluation (Social Environment)

Environmental Item		Evaluation and basis	
1	Resettlement	C	No house will be located on the construction site.
2	Economic activity, Land acquisition	C	River bed and bank is the governmental area. Though grit chamber is planned to be constructed next to the farm, it is small scale (approximately 50 square meters) and DNSAS can obtain consent of farmer.
3	Traffic, Facility for life	C	Construction will not stop local traffic. People and vehicle can pass by the side of the construction site.
4	Split of local community	C	Split of local community caused by the construction is not expected.
5	Cultural/ historical heritage	C	No impact on local culture is expected and historical heritage does not exist in the construction site.
6	Water right, Common right	C	Water right and common right to be protected does not exist in the construction site.
7	Health and sanitation	C	No possibility of deterioration of health and sanitary conditions is expected.
8	Waste	C	A large amount of surplus soil and construction waste will not be produced during construction.
9	Disaster (risk)	C	Construction will not make the risk of disaster such as landslide.

Table 1-3.2   Environmental Evaluation (Natural Environment)

Environmental Item		Evaluation and basis	
10	Topography and Geology	C	Large scale of quarrying, cutting and embanking are not planned.
11	Soil erosion	C	Soil erosion caused by the construction will not be expected.
12	Groundwater	C	Pumping up of groundwater is not planned.
13	Lake and river	C	Construction will not change river flow conditions drastically and water amount taken through intake will not increase after the project implementation.
14	Coastal / sea areas	C	The project site does not include coastal nor sea areas.
15	Flora and fauna	C	The project site does not locate in the protected area or sanctuary.
16	Meteorology	C	No change of meteorology due to the construction is expected.
17	Landscape	C	Construction will not make the landscape worse.

Table 1-3.3   Environmental Evaluation (Environmental Pollution)

Environmental Item		Evaluation and basis	
18	Air pollution	C	Exhaust gas of heavy vehicle is limited and the construction site is not close to the houses.
19	Water pollution	C	Though small scale concrete work is planned, the drainage will be put into temporary sedimentation basin and the top clear water will flow out.
20	Soil pollution	C	Toxic substance or chemicals will not be used.
21	Noise and vibration	C	Serious noise and vibration will not arise and the construction site is not close to the houses.
22	Subsidence	C	Pumping up of groundwater is not planned and land subsidence is not expected.
23	Odor	C	There is no source of odor.

Chapter 2 Contents of the Project

Chapter 2　Contents of the Project

2-1　Basic Concept of the Project

2-1-1　Overall Goal and Project Purpose

2-1-1-1　Overall Goal

Under the National Development plan of the Government of Timor-Leste formulated on May 2002, the following two (2) items of goal have been set with the highest priority.

(1) Eradication of extreme poverty
(2) Attaining of equitable and sustainable economic growth and enrichment of health, education and welfare for the people

In order to achieve this goal, in the water supply sector, a development strategy of "Water supply with sufficient, safe and sustainable manner" was adopted as the first priority given target. As the Bemos Raw Water Main, being the facility to be rehabilitated under the subject project, functions to avail water supply to Dili City, the overall goal of the project is defined as "To make it possible to avail the safe and sustainable water supply to Dili City".

2-1-1-2　Project Purpose

In the Sector Investment Plan (SIP) prepared in April 2006, it is stated that concerning Water Supply to Dili city there have been various projects implemented since 2000, however, further efforts (project implementation) are to be exerted to attain the goals as set under the National Development Plan as well as Millennium Development Goals. Due to the above, under the SIP, the DNSAS who is responsible for water supply sector listed up the following four (4) high priority projects as shown in the Table 2-1.1.

Table 2-1.1　High Priority Projects by DNSAS

1) Establishment of Water Tariff Collection System
2) Training for DNSAS personals
3) Improvement / rehabilitation of Dili Water Supply / distribution system
4) Sanitation Improvement for Atauro Island people

Among others, the subject project is to contribute to the priority project 3) above, and therefore the project purpose is set "To secure reliable water supply from Bemos river" through securing the facility's function and safety of Bemos Raw Water Main.

2-1-2　Project Outline

The purpose of the Present Project is to secure the function of Dili water supply system by assuring raw supply water continuously to the Bemos and Dill Central Water Treatment plants in Dill city even if the flood corresponding to the return period of approximately 50 years will occur in

Bemos river in future. In order to achieve the purpose, rehabilitation and protection of the Bemos raw water main which is the fundamental facility of the Dill water supply system were required urgently from the viewpoint of disaster-prevention.

High-priority facilities for rehabilitation were selected taking into consideration the degree of damage, importance, river flow condition of the reach and so forth as well as the maximum utilization of the sound portion as it is. In addition, the facilities to be rehabilitated are designed to have appropriate durability from the aspect of disaster-prevention and convenient structures for easier maintenance by DNSAS.

Furthermore, the Lower Service Reservoir and valve chamber in Bemos Water Treatment plant are to be rehabilitated based on the result of the additional field survey. Meanwhile, the construction schedule was planned in consideration of the matters to be concerned that the construction site is located in the narrow valleys having frequent flood and site working period is limited only in the dry season from May to October and there should be no disturbance to the raw water supply. The facilities which were judged to be appropriate for rehabilitation / improvement for sustainably maintaining and securing raw water main function are fourteen (14) structures.

The components of the Phases II Project, which are excluded from the Present Project and countermeasure for landslide, are shown in the following Table 2-1.2.

Table 2-1.2 Contents of Project Works

Work items	Length	Rehabilitation / Improvement manner
1 Structure No.9 Left bank terrace of Bemos river	50 m.	• Protection of existing pipeline by revetment and re-filling by sand and gravel
2 StructureNo.11 Mountain foot slope of left bank of Bemos river	179 m.	(Pipeline exposed section as per design, but many rock fall and strike the pipeline, so that) • Shifting of pipeline route and embedding
3 Structure No.12 Comoro river right bank Steep slope road section	100 m.	• Construction of dual purpose road and drain (concrete pavement with wheel guard) • Construction of road side protection works including pipe supports
4 Structure No.14 The Lower Service Reservoir & valve chamber of Bemos water treatment Plant	-	• Renovate the facilities to have the equal capacity and function with the existing ones
5 Structure No.15 Counter-measure for land slides at the access road to Bemos water treatment plant	-	• Construction of L-shaped retaining wall • Slope protection

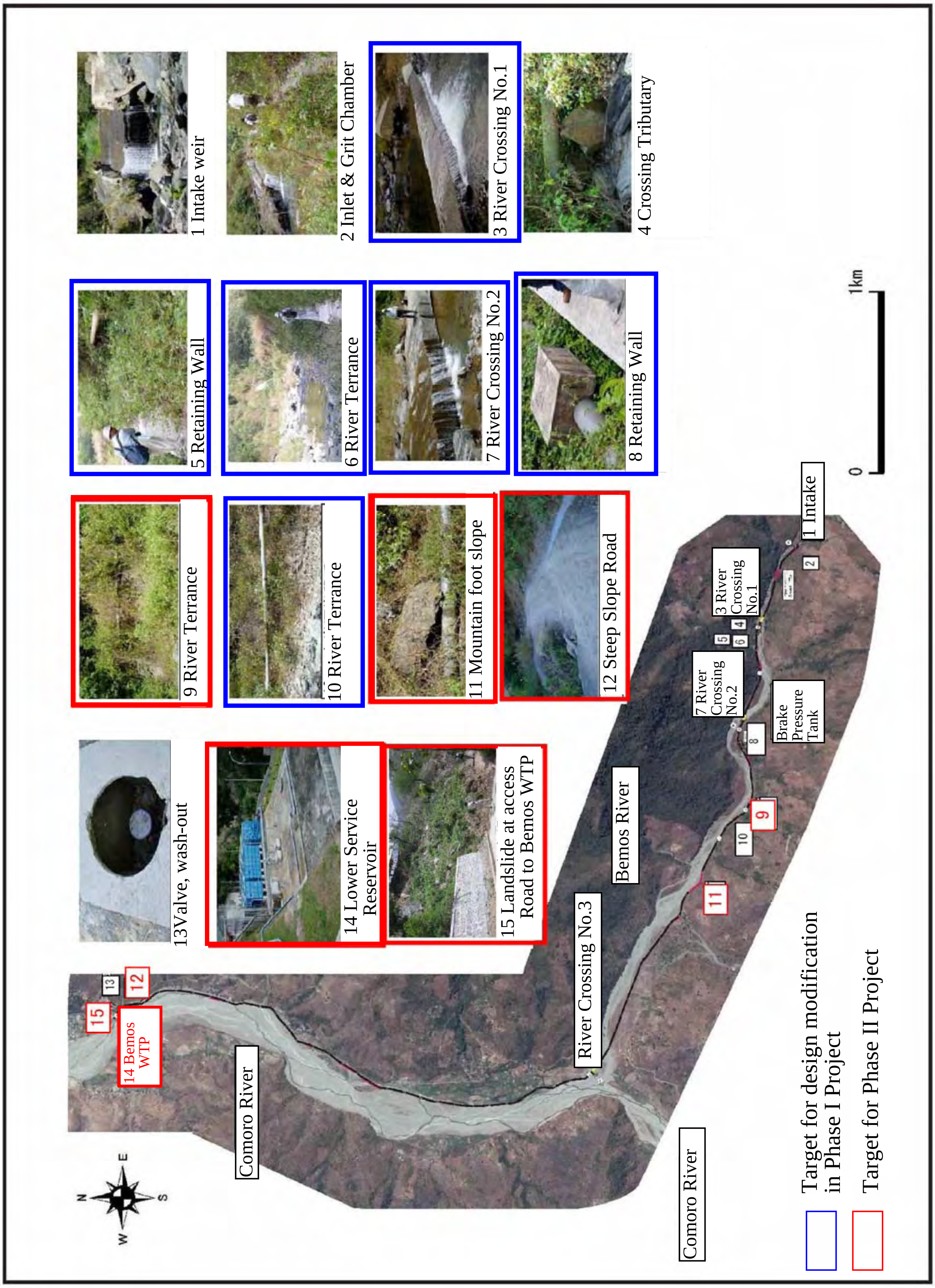


Fig. 2-1.1 Existing Conditions of Structures to be improved

2-2 Outline Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Scope of Request

The original component of the Present Project requested by the Government of Timor-Leste includes rehabilitation and improvement of the Bemos intake weir, the Bemos Raw Water Main from the Bemos Intake up to Bemos Water Treatment Plant, and improvement of the Lower Service Reservoir including the valve chamber. The raw water main has been rehabilitated with an emergency measure to recover its function by the Government of Timor-Leste when it suffered damages from floods occurred in 2004 and 2005.

In March and April 2010, unusual rainfall and floods occurred in the area of upstream of Bemos River. Floods caused further damages to existing main water pipe line facilities and extending the erosion and change of existing ground condition at the river bank of proposed structures. Therefore, it was necessary to modify the design in the Structures. After the consideration of importance and urgency for the rehabilitation among the Structures and further consideration of total project cost with proposed design changes, it had to exclude the some Structures from original components of the Present Project.

The components of the Phases II Project include the structures excluded from the Present Project and an additional structure (Counter measure to Landslide at Bemos Water Treatment Plant).

2-2-1-2 Basic Policy for Improvement of Raw Water Main

2-2-1-2-1 Basic Policy for Improvement

The basic policy for improving Raw Water Main Facility is as follows;

- Based on the investigation, usable parts of the facilities shall remain as it is or improved or rehabilitated. Renewal, new construction and relocation of the facilities are to be minimized, not replacing all facilities.
- The facilities to be rehabilitated are designed to have appropriate durability from the aspect of disaster-prevention and convenient structures for easier maintenance by DNSAS.

2-2-1-2-2 Standard and Criteria Applied

Not only rehabilitation works of the pipeline but also planning of the pipe protection works against rock fall and river flooding are included in the planning of improvement of the raw water main from the view-point of disaster-prevention in consideration of meteorology, hydrology and the river flow conditions including characteristics of flood. Those improvements are planned in conformity with the following Japanese standards because those of Timor-Leste for the planning to be based on are not provided yet.

- Design Criteria for Waterworks Facilities by Japan Water Works Association (2000)
- Manual for River Works, Ministry of Land, Infrastructure, Transport and Tourism
- Design and construction technical standard (draft) for revetment of the iron wire basket type, River Bureau, Ministry of Land, Infrastructure, Transport and Tourism
- Basic Policy of emergency restoration conserving a beautiful mountain and river, River Bureau, Ministry of Land, Infrastructure, Transport and Tourism
- Falling rock measures Handbook, Japan Road Association
- Planning and Design Standard of Land Improvement Project, Headworks, Agriculture Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan
- Planning and Design Standard of Land Improvement Project, Canal works, Agriculture Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan
- Planning and Design Standard of Land Improvement Project, Pipeline, Agriculture Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries, Japan
- Other relevant Standards, Manuals and Handbooks

2-2-1-2-3 Policy to Protection Works for Scouring, Boulder Stone and Rock Fall

(1) Protection Works for Pipelines Facilities Scoured by River Flow

Type and scale of the protection works are to be decided in consideration of the economy view points of the necessary height, the slope gradient, and the allowable velocity assuming to be an index of hydraulic condition of the river flow as obtained by the result of the hydraulic calculation. Protection works are to be provided in the cases that the raw water main or protection works of the existing pipeline are located at the water colliding point in the river or at the point of crossing the river channel and presently receiving damages of scouring or there is some possibility to receive such damages with the pipeline breakage or pipeline losses etc. when leaving it as it is.

① Plan of Revetment Work

- Basically, the revetment work is separately planned to have the low water channel.
- The revetment works of the low water channel is to be decided considering the economical view point as to the height of the low water channel and velocity at the control discharge in each repair portion.
- The revetment works of the flood channel is designed to follow the policies classified in the Table 2.1 according to the velocity at the design flood.
- When the exposed pipeline is protected from the river flow by revetment work, pipeline is buried w2-ith sand and gravel available at the site, and surface protection method of the revetment is selected as indicated in the Table 2-2.1 based on the velocity of the stream of the flood channel in the upper part of the pipeline.

Table 2-2.1 Revetment Works of the Flood Channel

Velocity of flood channel	Revetment works	Remarks
～ 1.0 m/sec	Possible by sand only	Maintenance is necessary after the flood
1.0 ～ 3.0 m/sec	Possible by gravel only	Maintenance is necessary after the flood
3.0 m/sec ～	Gabion, wet stone pitching works and concrete retaining wall	Necessity of prevention works of soil draw-out and type of prevention are judged by the situation.

② **Plan of Riverbed Protection**

- The application of type of protection work is selected in due consideration of the economical point based on the velocity in each rehabilitation portion at the design flood.
- Basically, length of riverbed protection area is designed to be 10 m for upstream and downstream reaches from the structure to be protected in accordance with the river protection sand erosion standard with increased or decreased adjustment as judged by the slope gradient of the river channel and undulating condition of the riverbed.

(2) Policy of Pipeline Protection to Rock Fall (boulder stone, fragmented rock)

As the result of the field survey on the falling rock of the pipeline route, it was found that "there are considerably big rock or fragmented rock lying scattered on the hillside slope in the upper part of the pipeline route, though falling not occurred so frequently, and there is a possibility of rock falling at a large earthquake or loosening of the ground by the heavy downpour. Therefore, the measure of protection work is necessary to avoid the damage on the raw water main (During the site survey, there found some damages on the pipe by rock fall though they are slight cave only on the pipe surface and not caused breakage).

The measure of protection works of rock fall is divided into two, the rock fall prevention works (measures against source) which stabilizes the fragmented rock and the rolling stone on the slope, and the defensive work against falling rock which protects the structure from the direct hit of the rock fall. The measure to be applied is the latter under this plan because the object is a raw water main which is the incidental facilities unlike the road that man is always using.

A basic policy of the rock fall protection measures which is derived from the result of the field survey is shown as follows.

- Portions of the raw water main where damage has been caused by the rock fall in the exposed pipeline section and where the dangers are confirmed be basically covered with the excavated sand. The earth covering of the raw water main needs to secure more than 60 cm thickness in order to function as soil cushion at the top of the pipe.

  It is presumed to endure the impact when the rock of about 0.5m in diameter falls from the height of about 5m right above the raw water main. This is judged from the result of the calculation referring to the falling rock measures handbook of the Japan Road Association in case that sand is assumed to be a buffer material and the earth covering is designed to be 60cm or more from the pipeline top. Moreover, the raw water main doesn't break even when the rock of about 0.7m in diameter falls from the height of about 10m and its rebound (the second fall) collides because there are a lot of sections where the distance between location of the hillside slope and the raw water main is away.

- The earth covering of the existing raw water main is 0.6m as the minimum, and damage by rock fall to the existing main has not occurred up to the present.
- When rain water or spring water infiltrates the slope, the ground loosens, and it is likely to cause the rock (including fragmented rock) slip and fall, the catch drain to drain rain water and spring water along the slope is installed and the ground is prevented from loosening.
- The boulder stone and the fragmented rock on the slope laid upper of the exposed raw water main can be removed comparatively easily, so, those rocks and stones be removed during the construction as much as possible.

2-2-1-2-4 Policy to Route Change

The route change is to be planned when it can be judged that change is advantageous in view of technical and economical points including the maintenance as compared with the case to maintain and repair the existing route. The following matters are to be considered in planning the route change.

- The pipe material to be used for repairing the raw water main is a carbon steel pipe (JIS G 3452 GSP or equivalent) as the same material of the existing one, and the basis of the fittings of the raw water main is a weld joint same as the existing raw water main. Moreover, the pipe is basically buried and the earth covering of the raw water main is more than 0.6m same as the existing one.
- The maximum interruption of the water supply time due to repair work of daytime is limited to be five hours from 10:00AM to 3:00PM based on the discussion result with DNSAS, and the suspension of the water supply days are limited within three days per week. Therefore, the non-suspension method which is commonly practiced in the waterworks in Japan is adopted, because it is difficult to complete the switch work of changing the pipe and valves by an ordinary method within five hours.
- Maintenance facility of the raw water main, which is necessary to meet the conditions of plan and profile of the raw water main and in the maintenance point of view, is planned appropriately.
- If necessary, the protection works to the scouring and rock fall is planned to the changed route.

2-2-1-2-5 Policy to Maintenance Facility for Raw Water Main

Operation and maintenance facilities, such as, sluice valve, air valve, wash-out and so on, for O & M of the raw water main are reviewed including the possible route change in order to maintain and improve the hydraulic condition and a system function of the raw water main. Moreover, the planning shall be made in a way that the re-arrangement of O & M facilities and route changes may cause a minimum effect on the hydraulic and structural conditions of the raw water main.

(1) Air Valve

Air valve is installed in principle at the following places;

- At the higher concave position along the pipeline.
- In the part that change suddenly into the descending inclination (more than 20°).
- At the immediate downstream of the sluice valve installed in the descending slope
- At the immediate upstream of the sluice valve installed in the ascent slope

The air valve newly planned is the rapid air valve ϕ80mm with repair valve, the same type of the existing one and the valve chamber is constructed to clarify the position of the valve and to facilitate the easy maintenance. However, the valve chamber is not provided where air valve is installed in the aqueduct.

(2) Sluice Valve Chamber

Sluice valve is installed in principle at the following places;

- Main branch points. To adopt the non-suspension method, sluice valve is necessary to be used when the pipeline is repaired in the project. The valve is installed on the branch side of the branch pipe and the interception side of existing main.
- At the wash-out point
- In the upstream of the river crossing in order to deal with the accident in the river crossing works
- Each of 1 to 3 km intervals even in the section without any specific reason and or the branch pipe in order to facilitate check and repair

Valve type is of sluice valve JIS B 2062 for water supply or equivalent. However, the valve of non suspension method might use the soft-seal type sluice valve for water service where the rust prevention measures and light-weighting were attempted. Moreover, the valve chamber is constructed to clarify the position of valve and to facilitate operation.

(3) Wash-out Valve and Facility

The wash-out facility is installed to exclude water and sediment in the pipeline when the pipeline is maintained and repaired. The wash-out facilities are installed in the point where it is near draining ahead in the lower position in the route. As the raw water main in the project runs along

Bemos River or Comoro River, drainage points of wash-out facility are Bemos River or Comoro River. As the amount of discharge of the wash-out is considered not causing the problem, wash-out facility is installed at the point where the pipeline is lowered more than surroundings basically.

As the branch pipe of Tee socket is ϕ80mm in diameter in the existing facilities, it is reported to cause the difficulty in maintenance because the branch diameter of Tee socket is small and there is a lot of inflow sediment. Drainage outlets of wash-out facility are either Bemos River or Comoro River and it doesn't have any specific limitation for draining. Then, the branch pipe of Tee socket is planned by ϕ200mm in diameter because it is convenient for a large amount of sediment evacuation with drain in a short time.

2-2-1-3 Policy on Improvement of the Lower Service Reservoir and Valve Chamber in Bemos Water Treatment Plant

2-2-1-3-1 Basic Policy for Improvement

The followings are the basic policies on the improvement of the Lower Service Reservoir and valve chamber in Bemos water treatment plant.

- Badly deteriorated structures or members that do not retain designed strength or have a risk of caving will be rebuilt. Repairable parts will be used continuously after the repair and improvement through this project.
- Reservoir: Service reservoirs in Bemos water treatment plant are of concrete made and the improvement method to be applied will be decided by the synthetic judgment on deterioration. Bases of the judgment are elapsed years after the construction, concrete compressive strength, degree of concrete neutralization, deformation and damage of members, leakage status and so on. Furthermore, it is noted that the reservoir improved by the selected method should be stable and watertight.
- Pipes and measuring instruments: Rusty pipes and valves that have difficulty in open-close operation should be replaced. Devices and parts of facilities which were newly installed at the time of renovation of water purification units in 2007 will be once dismounted and kept in storage, then will be installed again after the rebuilding of the reservoir.

2-2-1-3-2 Standard and Criteria Applied

Since technical criteria on renovation of waterworks facilities are not available in Timor-Leste, the following criteria in use in Japan will be applied to the improvement of the service reservoir of this project.

- Design Criteria on Waterworks (2000), Japan Water Works Association
- Guideline on Operation and Maintenance of Waterworks (2006), Japan Water Works Association

- Guideline on Renovation of Waterworks (2005), Japan Water Works Association
- Guideline on Functional Diagnostic of Waterworks (2005),
  Water Supply Division, Health Service Bureau, Ministry of Health, Labor and Welfare, Japan

2-2-1-4 Basic Policy for measurement of Landslide at the Access Road to Bemos Water Treatment Plant

As the result of the studies below based on the geographical survey, sounding test and soil physical test around the landslide site, the factors caused the landslide are consolidated as follows.

① Main factors caused the landslide

・ Old talus cone sediment is thickly distributed in the landslide inclined plane

→ By the observation of the out crops, the old talus cone sediment is highly consolidated and has a considerable strength in case of dried condition. However, due to high content of clay soil in the ground matrix, clay soil may become sliding plane when the ground matrix is placed for long period in wet condition moistened by seepage water of prolonged rainfall in the rainy season and/or ground water. Furthermore, a gentle dip slope of slate layer is considered being some effect to the landslide.

・ The sliding site is located at the forefront of ridged configuration

→ The landslide is occurred at the proximity of the tipped point of ridged shape configuration. The trace of the previous landslide can be observed at the neighboring west side slope which indicates that the geological character of slope is prone to cause a landslide. For this, it is considered that as the said ridge has been exposed to the Comoro river flow and eroded from the height of terrace (EL 80m) composed of river bed sediment and old talus sediment to the height of present river bed elevation (EL60m), the base ground has been loosened considerably.

② Inducement of Landslide

・ Rainfall in the rainy season

→ The area in the landslide zone where receives collected drain water of rainfall is estimated less than 1,000 m^2 in area. Since the catchment area is rather narrow if compare with the other slopes, it is considered that the slope has been rest in wet condition for long period and got clacks by the said loosing in the ground which has caused weakening of ground condition and sliding.

・ Ground Water Feeding from Base Rock of Hinterland

→ As the catchment area is so small that the ground water has some possibility to act upon the landslide. As the survey was conducted in the dry season, existence of ground water has not been recognized. However, soils adhered to the sounding rod (Macintosh penetration test machine) with high moisture content were found. It is envisioned that slate (the base rock) becomes fresher, harder and more impermeable in proportion to the depth, however, the upper portion of the base rock for a few meter may become softened and highly permeable due to weathered. As those potions may become water path and supply ground water to the landslide layer.

Taking the above matters into consideration, the countermeasures for the landslide are proposed as follows.

- Soft soil block slid shall be removed because of possibility to slide further due to increase of moisture content during the coming rainy season.

- The river bed sand and gravel and/or permeable material will be replaced with removed slid soil and the perforated pipe structure will be provided so as to drain rain water to outside immediately.

- As the strong structure is required at the end of landslide portion to cope with the earth pressure of the embankment and the base rock, the concrete retaining wall is constructed.

- The protection structure is provided at the surface of slope to restrain the further progress of side and upward slope corruption and to drain the surface and ground water quickly.

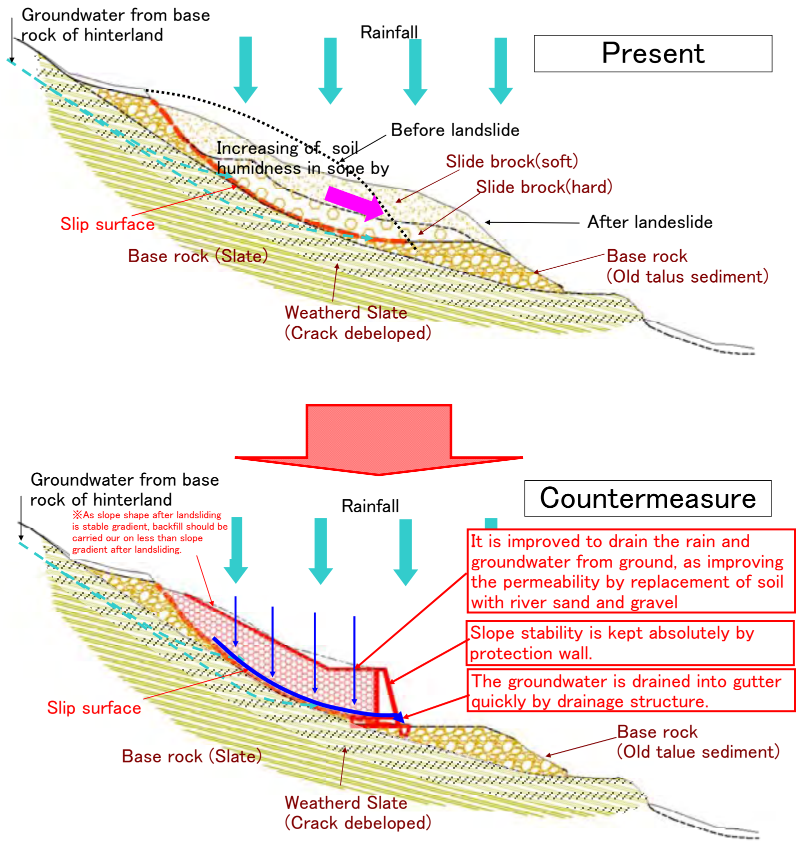


Figure 2-2.1 Design Concept on countermeasure for landslide

2-2-1-5 Policy towards Natural Conditions

Policy towards natural conditions is as follows;

- The project site is located under a climate of the tropical monsoon type where the rainy season and the dry season are clearly divided as shown in the following table. The climate has concentrated rainfall with a high intensity in the rainy season, causing frequent floods. Moreover, geographical feature in the site is of steep and the flood run-off speed is also very high. It is noted that the design should suit with such a climate pattern.

Table 2-2.2 Periods of Rainy Season, Dry Season and Average Monthly Rainfalls

Climate	Period	Average monthly Rainfall	Remarks
Rainy season	Nov. ～ April	115mm～156mm	In 1953～1999
Dry season	May ～ Oct.	15mm～74mm	Ditto

Data source: data from the Dili rain gauge station (1953 to 1999)

- The existing Bemos Raw Water Main is laid along the river channel of Bemos River and Comoro River. Especially, the Bemos River is a steep stream of 1/20 to 1/90 of the river bed slope, and a valley where both shores are sheer. In addition, outcrop of a sedimentary rock advanced by weathering is seen in the cliff of both shores, and the megalith and large rock exist together in the river bed. It is planned that the design should suit with such geographical and geological features.

- The monthly mean temperature of the project site is 27~29℃, the monthly mean maximum temperature is 30~33℃, and the highest temperature in daytime might rise as high as about 40℃. It is necessary that the design suits with such high temperature conditions at the project site.

2-2-1-6 Policy toward Socio-economic Conditions

Although DNSAS once started to collect water charge from city residents in some parts in Dili from 2004 after the Timor-Leste became independent, the collecting system was disturbed during the violent insurgency occurred in May 2006 and still has not been resumed to date. This implies that the financial resources of DNSAS as a water supply implementing body are not sufficient enough. Considering these financial conditions of DNSAS, gravity flow system taking advantage of terrain in upper reach of Bemos River will be applicable following the existing water supply system through Bemos water treatment plant including intake, raw water main, hydraulic design in the plant, and water distribution to the city. This is a policy to be continued to save the operation cost of the water supply.

It is necessary to take appropriate measures to deal with contaminated drain water and industrial waste produced through construction works. Likewise, blocking off the community road during the construction period should be as much as possible avoided. Since waterworks improvement project will provide little benefit to inhabitants of the village around the construction sites, employment of local residents living along Bemos River as unskilled labors for construction is preferable from the viewpoint of job-creation in the project area.

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

2-2-2-1 Intake Plan

The intake method at the Bemos intake weir is designed to be a natural inflow by gravity. Considering the capacity of Bemos WTP and Dili central WTP, a design intake discharge at the Bemos weir (discharge of raw water main) is calculated as follows.

Intake discharge at the Bemos intake: $Q = (Q_1 + Q_2) \times (1 + 0.1)$ [loss 10%]

$= (2{,}000 + 6{,}000) \times 1.1 = 8{,}800m^3/day$

$= 102$ liter/sec

Q_1: $2{,}000m^3/day$ (design capacity of Bemos WTP)

Q_2: $6{,}000m^3/day$ (design capacity of Dili central WTP)

2-2-2-2 Design Flood Discharge

2-2-2-2-1 Probability Year of Exceedance

According to the Technical Standard of River and Sediment Control edited by the Ministry of Land, Infrastructure and Transport Japan, it is mentioned that the scale of the river development plan depends on the value and the importance degree of the river with due consideration of current damage status, economical effect, etc. of the past flood.

In general, relation between the importance degree of the river and the scale of the plan are shown as follows.

Table 2-2.3 Importance of the River and Scale of the Plan

Importance Degree of River	Scale of the Plan by Precipitation (Probability of Exceedance)
Grade-A	More than 200 years
Grade-B	100 years ～ 200 years
Grade-C	50 years ～ 100 years
Grade-D	10 years ～ 50 years
Grade-E	Less than 10 years

Also, relation between the class of river and the importance degree of the river are shown as follows.

Table 2-2.4 Classification of the River and Importance of River

Class of River	Importance Degree of River
Main part of Class A river	Grade-A ～ Grade-B
Other part of Class B river	Grade-C
Urban river of Class B river	Grade-C
Unapplied river	Grade-D ～ Grade-E

The Bemos River is an ordinary one flowing through mountainous area and land side of the river is mountain range. According to the above tables, the importance degree of the Bemos river is evaluated as Grade-D of the ordinary river and its scale of plan is considered with probability 50 years of exceedance.

On the other hand, the daily rainfall of 50 year probability of exceedance is 122mm/day calculated from rainfall observation data in Dili and largest-ever daily rainfall in February, 2004 is 126.7mm/day. A basic flood of the project is estimated by the rainfall 126.7mm per day of the largest-ever daily rainfall in February, 2004, in consideration of the difference of both daily rainfalls above is only 4.7mm (about 4%) and having received damage due to the largest-ever flood.

Table 2-2.5 Probable Maximum Daily Rainfall in the Dili Rain Gauge Station

Return period	Probable daily rainfall (mm/day)	Remarks
2	72.0	
3	81.3	
5	90.8	
10	101.5	
20	110.9	
Year of 2005	113.4	Correspond to R.P. 24.4 year
30	115.9	
50	121.9	
Year of 2004 (largest)	126.7	Correspond to R.P. 76.6 year
100	129.6	
200	136.9	

2-2-2-2-2 Design Flood Discharge at the Point of Bemos Intake Weir

(1) Catchment Area

The catchment area of Bemos river and Comoro river is investigated in “the Study on Community-Based Integrated Watershed Management in Laclo and Comoro River Basins”, as shown on Table 2-2.6.

Table 2-2.6 Catchment Area of Bemos River and Comoro River

River Name	Catchment Area
Comoro river（river mouth）	212.0 km^2
Bemos river（Confluence point with Comoro）	43.9 km^2
Bemos river（Intake point）	30.3 km^2

(2) Design Flood Discharge at the Point of Bemos Intake Weir

Design flood discharge at the point of Bemos Intake Weir is estimated by a) method based on catchment data, such as probability maximum daily rainfall and catchment area, and b) data of flood overflow trace at the weir (1.2m in depth in left bank of major bed according to interview to the manager) and method based on river data at the intake weir point. Result by two methods is shown in the Table 2-2.7

In the table, b) data of flood overflow trace is (Interview) based merely on the memory after a lapse of several years and it is possible that observation data has been shifted from the time of the flood peak. It is therefore presumed to have given a small result.

Table 2-2.7 Result of Analysis for Flood Discharge at Bemos Intake Weir

Item	unit	(a) largest recorded flood	(b) largest flood with overflow mark at weir
1. catchment area	km^2	30.3	
2. daily rainfall	mm/day	126.7	Correspond to 90.2
3. rainfall intensity	mm/hr	33.6	Correspond to 23.9
4. design discharge	m^3/sec	198	141
5. flood water level of the upstream of weir	m	H.W.L.229.95m	H.W.L.229.55m
6. velocity at the upstream of weir	m/sec	5.59	5.03

Therefore, the design flood discharge at the point of the Bemos Intake weir for the Bemos river planning is adopted with the largest-ever maximum flood of 50 year probability of exceedance in consideration of the importance of the river structure, the influence of the flood struck, and so on.

- The largest-ever maximum flood: $Q_{max} = 198m^3/sec \fallingdotseq 200m^3/sec$
- Flood water level at the intake weir point: H.W.L.229.95m

(3) Design Flood Discharge for Revetment in the Low Water Channel (Control Discharge)

The river channel is formed due mainly to the flood that occurs once or twice a year. This flood discharge is called “Control discharge”. In case that the daily rainfall of 2 year probability of exceedance (72mm/day) from the result of the rainfall probability analysis is applied to the control discharge at the Bemos Intake weir covering the catchment areas of 30.3km^2 , it is presumed as follows.

Control Discharge: $Qc = 72mm/day \times 200m^3/sec / 126.7mm/month = 112.5m^3/sec \fallingdotseq 110m^3/sec$

Therefore, the height of the low-flow revetment is decided in a way the low water channel can accommodate the discharge of 110m^3/sec.

2-2-2-2-3 Specific Discharge of Design Flood at Tributary

Rainfall intensity within the time of flood concentration to the tributary is calculated as 53.9 mm/hr since 0.5 hr of the time of flood concentration in mountainous catchment and 126.7 mm/day of daily precipitation at the largest flood on Feb. 6, 2004, and the specific discharge of design flood at tributary is estimated at 10.5$m^3/sec/km^2$.

Moreover, the rainfall intensity of the control discharge at tributary (2 year probability of exceedance: 72mm/day) obtains 30.6mm/hr, and the specific control discharge at tributary is estimated at 5.95m^3/sec/km^2.

2-2-2-2-4 Design Flood Discharge and Control Discharge in Each Point

Design flood discharge and control discharge at each structure point (No.) are calculated based on the following specific discharges and shown in Table 2-2.8,

- Specific design flood discharge in the main river channel : q_{mf} = 200 / 30.3 = 6.60m^3/sec/km^2
- Specific control discharge in the main river channel : q_{mc} = 110 / 30.3 = 3.63m^3/sec/km^2
- Specific design flood discharge in the tributary : q_{bf} = 0.7 × 53.9 / 3.6 = 10.5m^3/sec/km^2
- Specific control discharge in the tributary : q_{mc} = 0.7 × 30.6 / 3.6 = 5.95m^3/sec/km^2

Table 2-2.8 Design Discharge and Control Discharge in each Station

No.	Name of facilities	station	Type of river	Catchment area (km^2)	Design discharge (m^3/sec)	Control discharge (m^3/sec)
No.9	Left bank river terrace of Bemos river	Sta.2+025 to 2+125	mainstream	37.8	250	140
No.11	Mountain foot slope of Bemos river left bank	Sta.2+365 to 2+570	mainstream	38.8	260	140
No.12	Steep slope road of Comoro river right bank	Sta.7+000 to 7+100	mainstream	206.2	1,360	750

2-2-2-3 Hydraulic Design of River Cross Section

2-2-2-3-1 River Cross Section Type

Composite section type like the figure below is applied for the river channel in the basic design of the river structure relating protection of raw water main. The control discharge is to be drained through low water channel and the design flood discharge is assumed to flow through low water channel and flood channel. However, when sufficient space cannot be secured, the simple section type is adopted. Width B of the low water channel of the riverbed is decided based on the observed width of the flow channel of the present river survey.

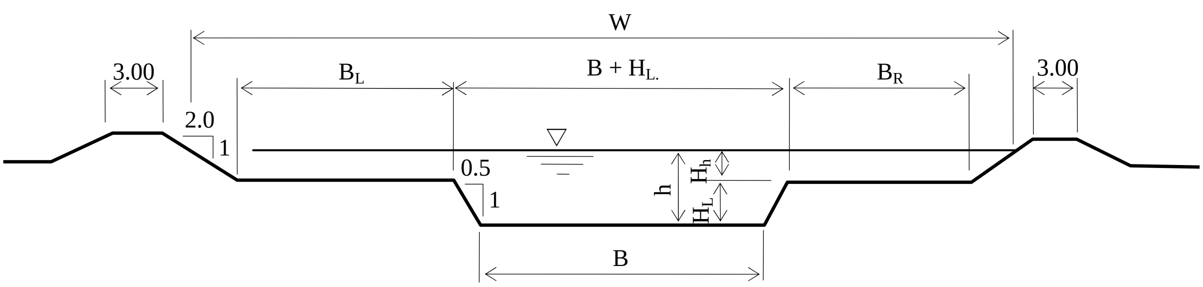


Fig. 2-2.2 Typical River Cross Section for Basic Design

2-2-2-3-2 Formula for Hydraulic Calculation of River Flow

(1) Formula of Velocity

Manning formula is adopted.

$$V = 1/n \cdot R^{2/3} \cdot I^{1/2} \quad \text{--} \quad (1)$$

Where V : Mean velocity (m/sec)

n : Coefficient of roughness、n = 0.040

R : Hydraulic mean depth (m)、R = A / P

A : Area (m^2)

P : wetted perimeter (m)

I : River slope

$$hv = V^2 / 2 \cdot g \quad \text{--} \quad (2)$$

Where、 hv : Velocity head (m)

g : Gravitational constant、g = 9.8m/sec^2

$$Fr = V / \sqrt{g \cdot h} \quad \text{--} \quad (3)$$

where、 Fr : Froude number

h : Water depth (m)

(2) Formula of Critical Tractive Grain Size

Iwagaki formula is adopted for calculating the critical tractive grain size.

$$d_{max} = U_*^2 / 80.9 \quad \text{--} \quad (4)$$

where、 d_{max} : Critical tractive grain size (cm)

U_* : friction velocity (cm/sec)、$U_* = \sqrt{g \cdot R \cdot I}$

2-2-2-3-3 Hydraulic Criteria in Each Structure (discharge, velocity, critical tractive grain size, etc.)

Table 2-2.9 shows the result of calculated dimensions of low water channel and flood channel based on the formula (1) to (4) , such as velocity, critical tractive grain size and so on which indicates the index for selection and the scale decision of the revetment and riverbed protection by the river slope and discharge in each structure station.

Table 2-2.9 Hydraulic Parameter of Design Discharge and Control Discharge at each Point

Location		Dischrge (m^3/s)	Slope	Bottom wudth B and BL + Bk (m)	Water dpeth H_L H_h (m)	Velocity of design discharge (m/sec)	Velocity of contril discharge (m/sec)	Type of flow	Critical tractive grain size (cm)	
									At design discharge	Ar control discharge
No.9	LWC	250	1/40	20.0	1.50	5.63	4.79	SCF	51.51	40.36
	FC	(140)		50.0	0.40	2.13	—	SCF	11.98	—
No.11	LWC	260	1/65	20.0	1.70	4.98	4.04	SCF	37.95	27.75
	FC	(140)		35.0	0.60	2.17	—	Sub-CF	10.92	—

2-2-2-4 Selection of Revetment

2-2-2-4-1 Revetment Type

The type of the revetment that can be adopted is as follows, considering the guidelines for material procurement and the maintenance, etc. as applied in Timor-Leste.

1) Revetment by gabion (easy material procurement, many positive records),
2) Revetment by wet masonry (easy material procurement and maintenance, many positive records),
3) Revetment by concrete (high stability and safety, easy maintenance)

Although a gabion is classified into the iron wire basket type and a wire-cylinder is also included in it in general, the iron wire basket means the gabion in the project because the wire-cylinder is unfamiliar in Timor-Leste.

2-2-2-4-2 Maximum Allowable Velocity of Revetment

The maximum allowable velocity of the revetment is set from “Design and construction technical standard (draft) for revetment of the iron wire basket type” and “Basic Policy of emergency restoration conserving a beautiful mountain and river” by River Bureau of Ministry of Land, Infrastructure and Transport, or “Planning and Design Standards of Land Improvement Project” by Ministry of Agriculture, Forestry and Fisheries, Japan as follows.

(1) Maximum Allowable Velocity in Design and Construction Technical Standard (draft) for Revetment of the Iron Wire Basket Type

There are following important restrictions in the applicable condition of the revetment of the iron wire basket type;

> “These cobblestone and boulder stone might collide with the iron wire at the flood, the iron wire be worn out, and the iron wire be broken in the section where the riverbed is composed of the cobblestone or the boulder stones larger than man’s head. Therefore, the application of this type of revetment is abandoned in such a section.” (referred to p.5)

It is considered that man’s head size means the cobblestone with the average diameter about 25cm. At flow velocity where such a cobblestone moves, judging from the figures in the Table 2-2.9 Design flood of the each structure point and hydraulic criteria of the control discharge" (low water channel in the vicinity of the second river crossing and the pressure reduction chamber to which the cobblestone of the average diameter about 25cm moves), the velocity at the control discharge is about 4.0m/sec in critical tractive grain size of about 25cm.

Therefore, the maximum allowable velocity at the control discharge for the revetment of gabion is limited at about 4.0m/sec.

(2) Design Velocity in Basic Policy of Emergency Restoration Conserving a Beautiful Mountain and River

The Table 2-2.10 is referred to a technical standard concerning the disaster relief work, and the standard at the design velocity in the disaster relief work of which the principle is in restoring to original form is shown. Moreover, it is noted that the material should deteriorate by aging which makes revetment unstable, even in case it is in the range at the application velocity".

It is necessary to make adequate adjustment in determining the maximum allowable velocity in case of the revetment method like gabion, wire-cylinder, wet stone pitching and wet masonry, where is fear of deterioration of iron wire and filling concrete by worn-out, cutting, abrasion of concrete and stone falling-off.

Table 2-2.10 Relation between Revetment Method and Design Velocity
(design velocity: Table velocity at design flood discharge)

Revetment Method		Design Velocity（m/sec）						
		2	3	4	5	6	7	8
Masonry	Natural stones（Dry masonry）							
	Natural stones（Wet stone pitching）							
	Natural stones（Wet masonry）							
Wire Basket	Gabion（gentler slope than 1：1.5）							
	Gabion（Flat placing）							
	Gabion（Multi-step placing）							

Note： Range that can be applied
Range not used basically (It is likely to use it by the characteristic of the river and the situation of the back yard)
(referred to p.36 of technical standard)

(3) Maximum Allowable Velocity in "Planning and Design Standards of Land Improvement Project Canal Works P.153" by Ministry of Agriculture, Forestry and Fisheries

Table 2-2.11 Max. Allowable Velocity of Main Materials
（velocity at the max. flow in irrigation canal）

Material	Max. Allowable velocity (m/sec)	Material	Max. Allowable velocity (m/sec)
Soft rock	2.0	Wet block protection wall	2.5
Medium rock	2.5	Concrete protection wall (thinner than 13cm）	1.5
Hard rock	3.0	Concrete protection wall (thicker than 13cm）	3.0
Dry block protection wall（below 30cm in depth）	1.5	Concrete protection wall （increasing 1.5cm covering of reinforcement bar）	6.0
Dry block protection wall（more than 30cm in depth）	2.0	Concrete protection wall （increasing 3.0cm covering of reinforcement bar）	9.0

Note: 3) 1.5 times of this table are applied to the discharge (probability discharge for 1 year or two years) to examine the revetment of the low water channel for drainage canal as a limit. The application of this table is excluded in the case of the riverbed protection in the chute and steep slope drainage or canal member reinforced by increasing concrete depth or adding reinforcement bar, or in big drainage canal that corresponds to the river. The maximum allowable discharge in this case is provided referring to a structure, geographical and geological features of a canal concerned, and a similar practical example.

5) In case of increase of concrete coverage of structure where is exposed to the stream and the velocity exceeds 3.0m/sec; whenever additional thickness of 1.5cm is increased to the concrete coverage of reinforced concrete structure (minimum concrete coverage: 5cm in case of severe corrosion environment), it is assumed that the durability of the structure can be secured and its allowable velocity also increases further by 3.0m/sec in addition to the figures shown in Table 2.11 according to the design criteria of the bureau of development in the United States.

(4) Maximum Allowable Velocity and Applicable Condition of Revetment in River Rehabilitation Work

The applicable condition of each revetment work method is set in consideration of the following points as shown in Table 2-2.12.

- The maximum allowable velocity of revetment of the iron wire basket type (gabion) is about 4.0m/sec.
- Referring to the example of executing the river revetment work in Timor-Leste (Urgent Irrigation Rehabilitation Project of Lacro Irrigation System in Manatuto District. The Project for Rehabilitation and Improvement of Maliana I Irrigation System in Bobonaro District, Urgent Irrigation Rehabilitation Project of Seical-up Irrigation System in Baucau District) as mentioned in note 3) above,, the adjustment coefficient of the allowable velocity for “wet masonry revetment wall” and “thick concrete retaining wall (normal covering)” is assumed to be 2.0 to the allowable velocity of irrigation canal revetment indicated in “Planning and Design Standards of Land Improvement Project, Canal Works” by Ministry of Agriculture, Forestry and Fisheries.
- The allowable velocity of a wet masonry revetment wall (0.3m in thickness) is assumed at 3.0m/sec and further the adjustment coefficient of 2.0 is applied to it as the same manner as the above-mentioned.

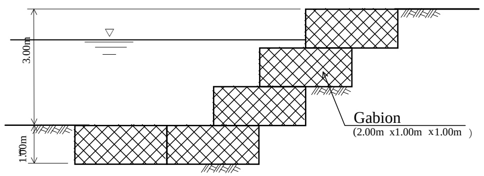
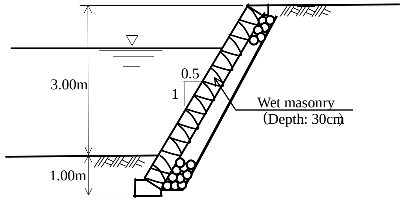
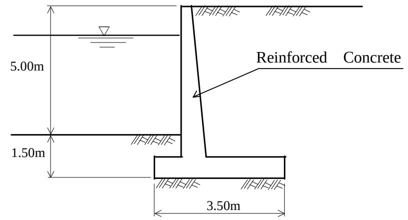
In the application of the revetment method, it is decided it considering the characteristic of each revetment method shown in Table 2-2.12 Revetment of River together with the applicable condition shown in Table 2-2.13.

Table 2-2.12 Adaptable Conditions for Revetment (velocity at the control discharge)

Type of material	Economic efficiency	Max. height (m)	Slope	Max. allowable velocity (m/sec)
Gabion	third	4.0	1 : 0.5 - 1.0	4.0
Wet masonry (approx. 30cm in depth)	first	3.0	1 : 0.3 - 1.5	6.0
Wet masonry (approx. 50cm in depth)	second	5.0	1 : 0.3 - 1.5	7.0
Plain concrete (gravity type, more than ordinary thickness of 13cm)	4th	4.0	1 : 0.0 - 1.5	6.0
Plain concrete (gravity type, add 1.5cm to the ordinary thickness)	5th	4.0	1 : 0.0 - 1.5	9.0
Plain concrete (gravity type, add 3.0cm to the ordinary thickness)	6th	4.0	1 : 0.0 - 1.5	12.0
Reinforced concrete (reversed T type or Leaning type, ordinary cover of 5.0cm)	7th	7.0	1 : 0.0 - 1.5	6.0
Plain concrete (reversed T type or Leaning type, larger cover of 6.5cm)	8th	7.0	1 : 0.0 - 1.5	9.0
Plain concrete (reversed T type or Leaning type, larger cover of 8.5cm)	9th	7.0	1 : 0.0 - 1.5	12.0
Plain concrete (buttress type, ordinary cover of 5.0cm)	10th	12.0	1 : 0.0 - 1.5	6.0
Plain concrete (buttress type, larger cover of 6.5cm)	11th	12.0	1 : 0.0 - 1.5	9.0
Plain concrete (buttress type, larger cover of 8.5cm)	12th	12.0	1 : 0.0 - 1.5	12.0

Note: Maximum height shown in the table refers to “standard design of civil structures vol. 2 Retaining Wall etc., Ministry of Construction as published by Kensetsu Gijyutsu Kyokai.

Table 2-2.13 Revetment of River

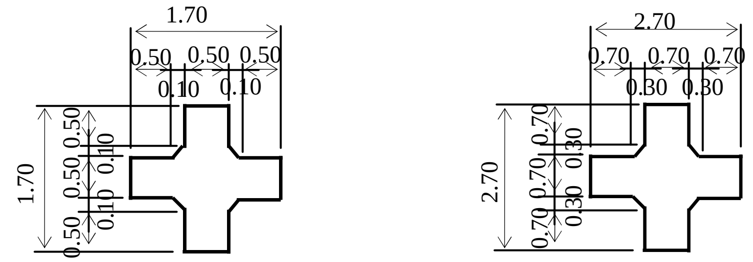
Item	1. Gabion revetment	2. Wet masonry revetment	3. Concrete revetment
Sketch			
Materials and Structure	・ Materials of Gabion (1.00m×1.00m×2.00m) can be procured in local. ・ The geotextile sheet is necessary for the prevention of back soil draw out. ・ As it is gabion, maximum is about four steps (4.00m in height).	・ Materials are stones (depth:30cm) and the structure is wet masonry by mortar. ・ Gravels are necessary for backfilling. ・ 5.00m in height is a limit. in the Japan standard.	・ It is a concrete structure. ・ Up to 4.0m in height: gravity retaining wall (plain concrete) ・ Up to 7.0m in height: Reversed T type or Leaning type retaining wall. (reinforced concrete) ・ Up to 12.0m in height: buttress type (reinforced concrete)
Durability	・ The maximum allowable velocity is approx. 4.0m/sec. ・ It deforms easily in case of the occurrence of riverbed scouring in front of revetment. ・ As the iron wire of the gabion rusts, durability is comparatively low. (poor)	・ The maximum allowable velocity is approx. 6.0m/sec to 7.0m/sec. ・ It is safe up to the penetration depth for riverbed scouring in front of revetment. ・ It is the most excellent for an impact and wear and abrasion resistance against drift stones of floods. (fair)	・ The maximum allowable velocity is approx. 6.0m/sec in case of ordinary reinforced bar cover. ・ It is safe up to the penetration depth for riverbed scouring in front of revetment. ・ It is excellent for an impact and wear and abrasion resistance against drift stones of floods. (good)
Construction efficiency	・ As a concrete work is unnecessary, construction efficiency is good. ・ The procurement of good quality stone is needed. (good)	・ As a concrete work is a little, construction efficiency is good. ・ The procurement of good quality stone and the skilled mason is needed. (fair)	・As it is a concrete work, construction efficiency is poor. ・ As it is a concrete work, enough drainage during construction is needed. (poor)
Operation and maintenance	・ As durability is poor, maintenance by repair is required. ・ The procurements such as stone and gabion nets necessary for the repair are easy. (poor)	・ As durability is excellent, maintenance of the facility. ・The procurements such as stone and a concrete and mortar necessary for the repair are easy. (fair)	・ As durability is excellent, maintenance of the facility. ・To repair, the procurement of the concrete materials are required. (good)
Economic efficiency	・ As it is a local material, the cost of construction is low. ・ As frequent repair is needed, the maintenance cost is considerable. (fair)	・ As it is a local material, the cost of construction is comparatively low. ・As durability is the most excellent in stream and rapid river, the maintenance cost is comparatively low. (good)	・ As it is a concrete structure, the cost of construction is high. ・ As durability is high in the ordinary river, the maintenance cost is comparatively low. (poor)

2-2-2-5 Selection of Riverbed Protection

2-2-2-5-1 Type of Riverbed Protection

The type of the riverbed protection including foot protection work that can be adopted is as follows, considering the material procurement and maintenance.

1) Riverbed protection by gabion (easy material procurement and a lot of positive records)
2) Riverbed protection by rubble foundation (easy material procurement and maintenance, a lot of records)
3) Cast-in-place concrete block (high stability and safety, low economy)



3 ton class Block   8 ton class Block

Fig. 2-2.3 Cast-in-place Concrete Block

The concrete blocks with unique shapes having many positive construction records in Japan cannot be adopted because it is expected that the procurement of the form is difficult. Therefore, cast-in-place concrete block having the shape illustrated in the Fig. 2-2.3 is applied for the project.

2-2-2-5-2 Standard of Riverbed Protection

The standard of riverbed protection (weight, size) is decided according to the velocity that collides with riverbed protection.

(1) Riverbed Protection by Gabion

As well as the revetment by gabion, the maximum allowable velocity of the riverbed protection by gabion becomes 4.0m/sec.

(2) Riverbed Protection by Rubble Foundation

Table 2-2.14 Max. Allowable Velocity of Riverbed Protection by Rubble Foundation （velocity at the design flood discharge）

Max. allowable velocity V （m/sec）	2.0	3.0	4.0	5.0	6.0	7.0	8.0	Remarks
Weight of steady rubble W （tf）	0.007	0.074	0.415	1.584	4.728	11.92	26.56	Based on equation (5) applying y = 0.86
Diameter of steady rubble d_k （cm）	14.4	32.4	57.5	89.9	129.4	176.2	230.1	Based on equation (6) applying y = 0.86

According to the “Water area reclamation and filling-up reclamation, Handbook on Irrigation, Drainage and Reclamation”, weight and diameter of steady rubble to the flow is as follows.

$$W = \frac{\pi \cdot \gamma r \cdot V^6}{48 \cdot g^3 \cdot y^6 \cdot (S_r - 1)^3 (\cos\alpha - \sin\alpha)^3} \text{ --- } (5)$$

Where、W : Weight of steady rubble（tf）
V : velocity（m/sec）
y : coefficient of shape (boulder stone), y = 0.86
(Burial stone), y = 1,20
γ_r : Unit weight of rubble, γ_r = 2.65tf/m^3
Sr : Specific weight of rubble, Sr = 2.65
α : Slope inclination, α = 0°
g : acceleration of gravity, g = 9.80m/sec^2

$$d_k = \frac{V^2}{2g \cdot y \cdot (S_r - 1)(\cos\alpha - \sin\alpha)} \text{ -- } (6)$$

Where、 d_k : diameter of steady rubble（m）

(3) Cast-in-place Concrete Block

According to "Head Works Design Standard of MOAFF", the riverbed protection block at the downstream should resist the flow power, and be steady. The standard size of the block per 1 piece is given by the following equation.

$$W > 3.75 \cdot A \cdot V^2 / 2g \text{ --- } (7)$$

$$V < \sqrt{\frac{2 \cdot g \cdot W}{3.75 \cdot A}} \text{ -- } (8)$$

Where W : Weight of block per piece（tf/piece）
A : Area with which flow collides、A = 2.70m×0.30m = 0.81m^2
V : velocity when flow collides with block、V = 6.59m/sec
g : acceleration of gravity、g = 9.80m/sec^2

Table 2-2.15 Max. Allowable Velocity of Riverbed Protection by Cast-in-place Concrete Block （velocity at the design flood discharge）

Type of block	3ton	8ton
Dimension (m)	1.70×1.70×1.00	2.70×2.70×1.00
Weight（tf）	3.45	8.15
Area of collision（m^2）	1.70×0.30 = 0.51	2.70×0.30 = 0.81
Max. allowable velocity（m/sec）	6.0	7.5

2-2-2-5-3 Applicable Condition of Riverbed Protection (foot protection works)

According to the above study, the applicable condition of riverbed protection (including foot protection works) is as follows;

Table 2-2.16 Applicable Conditions for Riverbed Protection (velocity at the design flood discharge)

Type of material	Size	Economic efficiency	Maximum allowable velocity (m/sec)
Gabion riverbed protection	1.0m×1.0m×2.0m	first	4.0
Riprap riverbed protection (average diameter 30cm)	ϕ 250 to ϕ 350	second	2.5
Riprap riverbed protection (average diameter 50cm)	ϕ 400 to ϕ 600	third	3.5
Cast-in-place concrete block riverbed protection（3ton）	1.70×1.70×1.00	4th	6.0
Cast-in-place concrete block riverbed protection（8ton）	2.70×2.70×1.00	5th	7.5

2-2-2-6 Raw Water Main

2-2-2-6-1 Raw Water Main System

(1) Raw Water Main System and Hydraulics

The water supply method of the Bemos raw water main is a natural gravity system as same as the existing one.

① Design Discharge

The design discharge in each section of the Bemos raw water main is as follows.

From intake weir up to the break pressure tank Q = 102 liter/sec
From the break pressure tank up to Bemos WTP branch Q = 102 liter/sec
From Bemos WTP branch up to No.8 isolating valve Q = 76 liter/sec
From Bemos WTP branch up to Bemos WTP Q = 26 liter/sec

② Type of Pipe, Diameter and Length of Raw Water Main

The total length of raw water main under this plan becomes 7,076m including 80.2m of the open canal section from the intake weir up to the grit chamber, showing an extension increase of 13m comparing the total length of the existing one, 7,063m including 6m in length of the break pressure tank as shown in Table 2-2.4. The quality of GSP is required to be equal to the carbon steel pipes (JIS G 3452) or higher.

Table 2-2.17 Type of Pipe, Diameter and Length of Raw Water Main

Section of raw water main	Type of pipe	Diameter (mm)	Length of raw water main (m)		
			Existing	After rehabilitation	Changes in length of raw water main
Intake weir up to the break pressure tank	GSP	250	1,355	1,287	・to place open canals from the intake weir up to the grit chamber: -80.2m ・to remove the pipes at the rehabilitation No.5 point: + 8.6m ・to remove the pipes at the rehabilitation No.6 point: +4.0m
The break pressure tank up to Bemos WTP branch	GSP	300	5,465	5,472	・to remove the pipes at the rehabilitation No.10-3 point: +7.0m
Bemos WTP branch up to No.8 isolating valve	GSP	300	237	237	—
Total			7,057	6,996	-60.6m

③ Water Level at each Facility and Head Loss of Raw Water Main

Hazen-Williams equation is adopted for hydraulic calculation of raw water main.

$$V = 0.355 \times C \times D^{0.63} \times I^{0.54}$$
$$Q = 0.279 \times C \times D^{2.63} \times I^{0.54}$$
$$I = hf / L = 10.667 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85}$$

Where, V: velocity (m/sec), Q: discharge (m^3/sec), I: hydraulic gradient,
D: diameter of pipe (m), C: coefficient of velocity,
L: length of raw water main (m), hf: head loss (m)

Though the C value of flow velocity coefficient changes depending on the type of pipe, the lining, the pipe diameter and the years of usage, etc., when the winding part loss etc. are separately calculated, the C is assumed to be 100 for GSP and 130 for ductile cast-iron pipe with mortar lining (DIP). Moreover, the bend sections in the raw water main are less than that of the distribution pipes etc. Therefore, head loss other than the friction loss in the raw water main is estimated as assumed 5% or less based on the experience, therefore, the loss is adopted as 5%.

Calculation results of hydraulic computation are shown in the Table 2-2.18 and Fig. 2-2.4 schematic diagram below.

Table 2-2.18 Hydraulic Computation of Bemos Raw Water Main

Location	Pipe Material	Design Discharge Q (m^3/s)	Pipeline Length L (Km)	Pipe Diameter D (mm)	No.of Pipe N (row)	Discharge /row q (m^3/s)	velocity coeffic. C	velocity V (m/s)	Hydraulic Gradient I (m/Km)	Loss Head H(=LxI) (m)	Energy Elevation (WL) (m)
1 Dili Central W.T.P.											**81.9**
(DIP φ300)	DIP	0.0764	5.055	300	1	0.0764	130	1.081	3.957	20.002	
2 No.7 + 62.00											**102.9**
(SGP φ300)	SGP	0.0764	0.237	300	1	0.0764	100	1.081	6.429	1.524	
3 No.6 + 900.00 (Branching Point)											**104.5**
(SGP φ300)	SGP	0.1019	5.472	300	1	0.1019	100	1.442	10.953	59.936	
4 Break Pressure Tank											**167.4**
5 Break Pressure Tank											**167.4**
(SGP φ250)	SGP	0.1019	1.287	250	1	0.1019	100	2.076	26.617	34.256	
6 Bemos Intake											**203.4**
										(<Grit Chamber	**226.65m**
7 Bemos W.T.P.											**100.4**
(SGP φ200)	SGP	0.0225	0.300	200	1	0.0225	100	0.716	4.825	1.448	
3 No.6 + 900.00 (Branching Point)											**101.9**
											(<104.5)

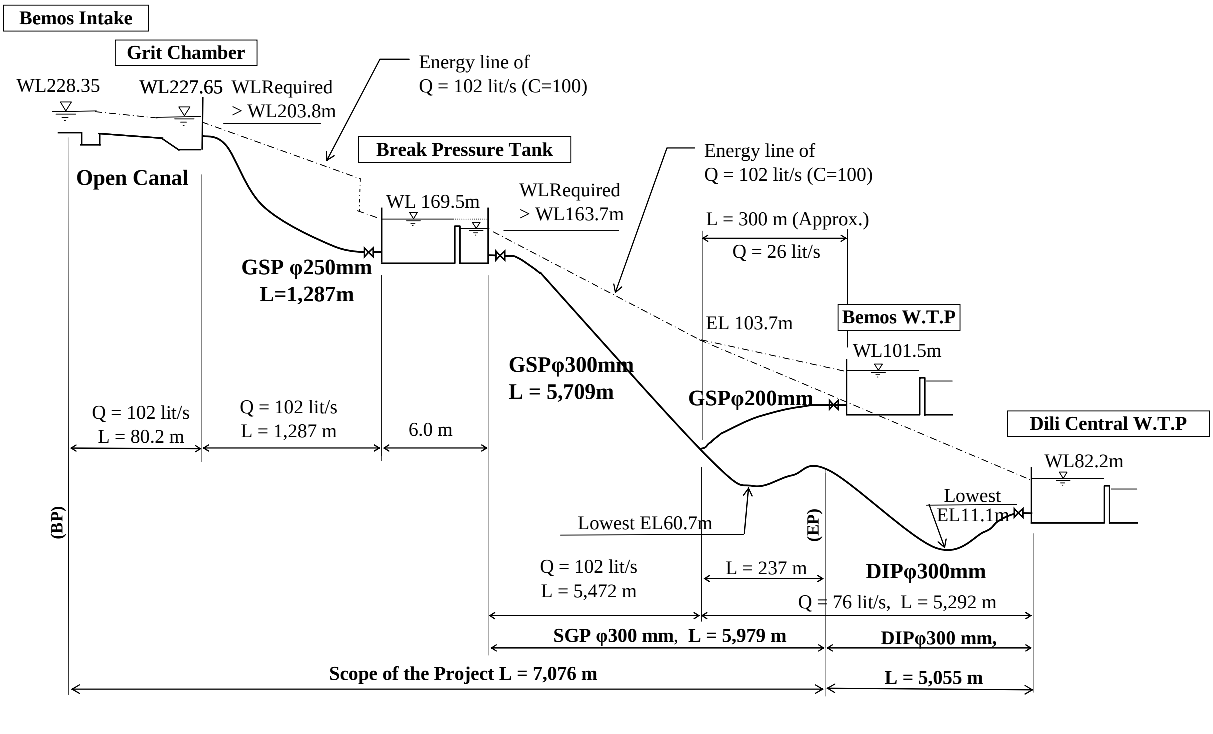


Fig. 2-2.4 Schematic Hydraulic Profile of the Bemos Raw Water Main

As the results of hydraulic computation, the design discharge can flow in each section of the raw water main. In the section (pipe diameter 250mm) from the grit chamber to the break pressure tank, the required head with which the design discharge may flow is about 36m against the effective head of 59.25m (=W.L.226.65m-W.L.167.4m), and the design has the head of about 23m allowance. On the other hand, in the downstream section of the break pressure tank, it is necessary to examine within the range to the Dili central WTP where the pipelines are consecutive. The required head which the design discharge may flow is about 85.5m against the effective head of 85.5m (= W.L.167.4m-W.L.81.9m), so the design has no allowance. This shows that flowing of the design discharge becomes difficult at once when a flow interruption such as accumulation of air and sedimentation of soil and sand in the pipes occurs, and it suggests that the periodic maintenance for the pipelines is quite important.

(2) Strength of Raw Water Main

The strength of raw water main to the external pressure on GSP ϕ 250mm and ϕ 300mm was confirmed with the calculation of the deflection and the bending stress intensity of the pipes by changing the allowable internal water pressure and overburden estimated for the thickness of the pipes. It was confirmed that the pipes had enough strength for use in this project. The results are shown below.

Table 2-2.19 Strength of GSP ϕ 300mm

Outside diameter: Do	mm	31.85					
Inside diameter: Di	mm	30.47					
Pipe wall thickness: t	mm	0.69					
Unit weight	t/m	0.0530					
Allowable stress	kg/cm^2	1,275					
Allowable internal pressure	kg/cm^2	45.3					
Overburden	m	0.3	0.6	1.0	1.5	2.0	5.0
Deflection	%	0.63	0.34	0.25	0.23	0.25	0.24
Allowable deflection	%	5.0					
Bending stress intensity	kg/cm^2	649	355	256	242	263	243
Allowable bending stress intensity	kg/cm^2	1,275					

Table 2-2.20 Strength of GSP ϕ 250mm

Outside diameter: Do	mm	26.74					
Inside diameter: Di	mm	25.42					
Pipe wall thickness: t	mm	0.66					
Unit weight	t/m	0.0424					
Allowable stress	kg/cm^2	1,275					
Allowable internal pressure	kg/cm^2	51.9					
Overburden	m	0.3	0.6	1.0	1.5	2.0	5.0
Deflection	%	0.44	0.24	0.17	0.16	0.18	0.16
Allowable deflection	%	5.0					
Bending stress intensity	kg/cm^2	511	279	202	191	207	191
Allowable bending stress intensity	kg/cm^2	1,275					

(3) Design Internal Pressure of Raw Water Main

As there is a free water surface at the break pressure tank within the raw water main, it is necessary to consider about an internal water pressure while acting on the Bemos raw water main dividing into 2 sections, the section from Bemos intake inlet to the breaking pressure tank and the section from the breaking pressure tank to Bemos WTP. As both of the sections have the isolating valve at the end, they are classified as a closed type pipeline. The design internal water pressure in the closed type pipeline is usually assumed to have added the water hammer pressure to the hydrostatic pressure. Based on calculation results of water hammer pressure (by Allievi's formula), the figure of the hydraulic pressure of Bemos raw water main where each pressure line of hydrostatic, dynamic water level and water hammer pressure are plotted in the profile of Bemos raw water main is shown in Fig. 2-2.5.

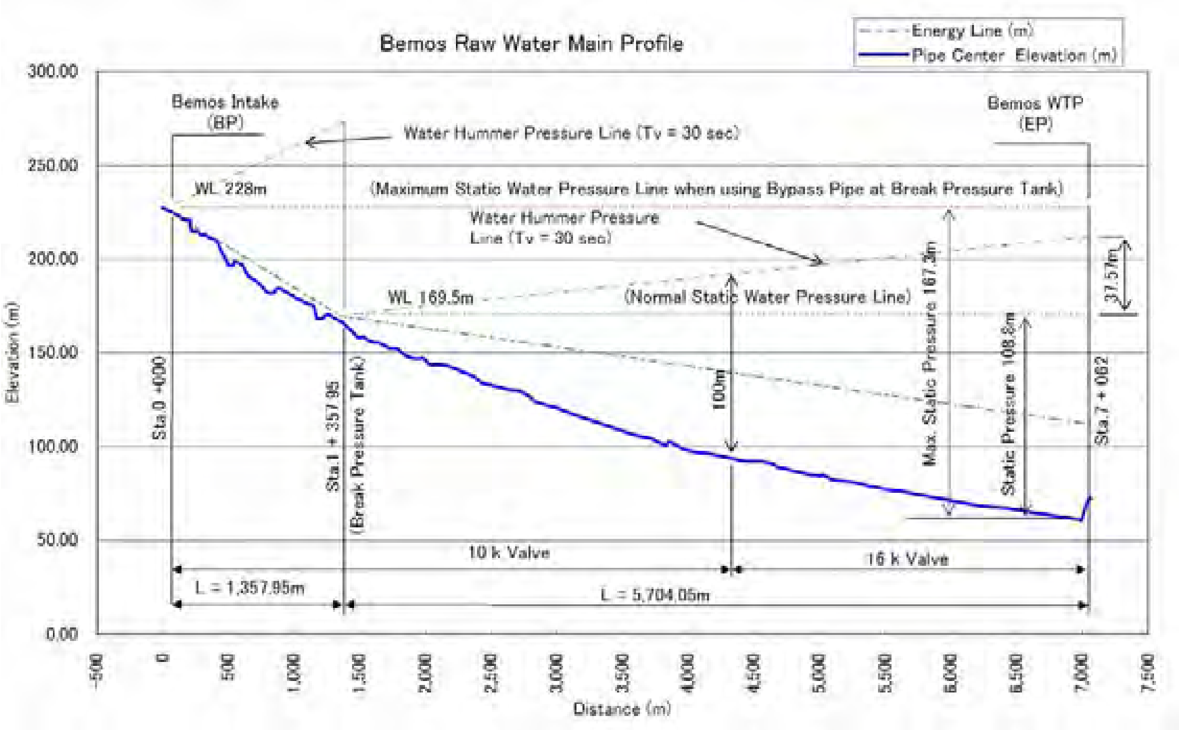


Fig. 2-2.5 Hydraulic Pressure of Bemos Raw Water Main

In the section from the Bemos intake to the break pressure tank, the maximum hydrostatic pressure is 58.5m (=228m-169.5m), and the water hammer pressure gives the maximum value by the case to shut the inflow valve (sluice valve) of the break pressure tank at the measuring point of about 1,355m, and is estimated to be about 46m at the point of inflow valve in the effective closing time of 30 seconds. If it is assumed to be an operating condition to close the sluice valve at the time of about 60 seconds or more, and the maximum acting pressure is about 104.5m at the position of the break pressure tank inflow valve (sluice valve). Therefore, it can be judged that the pressure standard of valves and flanges in this section is good in 10k.

In the section of the break pressure tank to Bemos WTP, the maximum hydrostatic pressure is 108.8m (=169.5m-60.7m) at the measurement point of about 7,000m which is the lowest altitude position of the raw water main, and the water hammer pressure gives the maximum value by the case to shut the No. 8 isolating valve (sluice valve) of the measurement end point of 7,062m, and is estimated to be about 38m in the effective closing time of 30 seconds.

When No.4 isolating valve located in the middle of the measurement point of 3,900m is operated to the close, it is a water hammer pressure of about 14m. Therefore, the maximum design pressure (= hydrostatic pressure + water hammer pressure) is about 147m at the measurement point of about 7,000m where is located at the lowest altitude (No.4 Wash-out point) of the raw water main, and the highest hydraulic pressure line has changed in straight line toward the break pressure tank. Accordingly, the maximum pressure acting on the pipeline becomes an internal water pressure of about 150m and 100m nearby at the measurement point of 4,300m and 7,000m respectively.

Based on the examination as mentioned above, the pressure standard of valves and flanges should require 16k for the upstream part from the measurement point of 4,300m and 10k for the downstream part.

Based on the above-mentioned calculation results, it is assumed that the maximum internal water pressure of about 15kgf/cm^2 acts to the downstream part of Bemos raw water main. The steel pipes used for the raw water main are carbon steel pipes for piping (JIS G 3452 GSP), and the use of the same pipe is limited to 10kgf/cm^2 in various standards. The examination water pressure for the pipes is 1.5 times (25kgf/cm^2/1.5=16.7kgf/cm^2) of maximum allowable working pressure. They are considered possible to utilize up to the pressure of about 16kgf/cm^2 because of the actual examination water pressure of 25kgf/cm^2. Therefore, it is judged that the pipes have enough strength for resisting pressure.

2-2-2-6-2 Basic Design for Improvement of the Facilities

(1) Structure No.9: Bemos Left Bank Terrace（Near IP.42：Sta.1 + 938）

The raw water main in this section has been exposed and has a risk of damage by the falling rocks. Further, as the flood will affect to the pipeline, the existing pipeline will be buried at the backside of the revetment to protect from flood and falling rocks.

① Planning for Revetment and Riverbed Protection

The wet masonry revetment with the slope of 1: 0.5 and 0.3m in depth is selected for the low water channel based on the velocity of 4.78m/sec at the control discharge. The height of the revetment is principally set at 1.5m although it is actually varied in accordance with the pipe elevation. The pipe coverage is buried with 0.6m in thickness as the minimum to protect from falling rocks.

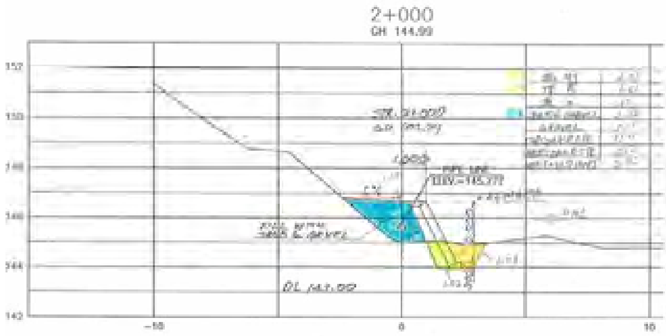


Figure 2-2.6 Typical Section for No.9 Rehabilitation Plan

Although the water level in the design flood is estimated at higher than the revetment of the low water channel, the flood channel will be covered by the mixture of sand and gravel available in the site, as the velocity of the flood channel at the design flood is estimated at 2.13m/sec.

In addition, the groin composed of gabions still remains in this section. At the part where the wet masonry revetment will be constructed on the gabion, it will be replaced with the plain concrete foundation of the revetment.

(2) Structure No.11: Bemos River Left Bank Steep Slope Mountain Foot (Sta.2 + 365 ～ Sta.2 + 570)

In this section, many unsteady stones are scattering on the heavily weathered stone surface of the left bank slope above the pipeline. The existing pipeline has been constructed as the exposed type and the fallen rock contacts with the pipeline at the vicinity of Sta.2+413 (IP.50) and many fallen rocks are scattering around the pipe and scarce damage is found on the surface of the pipe. Accordingly, the existing pipeline is utilized further with protection from a rock fall by means of burying at the backside of the revetment to be provided at the river side of the pipeline taking into account the possible damages by rock fall in future.

At basic design stage, the plan was made based on the completion drawings, it was not necessary to install new facilities such as air valve and wash out due to no fluctuation of pipeline in this section. And also, only one light damage point was found in this portion, it was evaluated that exiting pipeline was able to be used.

However at detail design stage, the topographic survey and longitudinal survey of this section pipeline was carried out, it was found that this section pipeline has three bumpiness and there were new two heavy damaged portions on pipe fallen by rock. Especially, longitudinal bumpiness of pipeline is not acceptable without necessary facility, because water flow is retarded due to air at protrusion and sand at concave portion in pipeline. Allowance of water head is very few for downstream portion of 300mm diameter pipeline from the brake pressure tank, therefore it is necessary to improve.

Therefore, at the view point of stable hydrological flow of pipeline and maintenance and cost, design was modified as follows; pipeline is rerouted with covering on top by wet masonry to protect from falling rocks and wet pitching retaining wall to protect river flow.

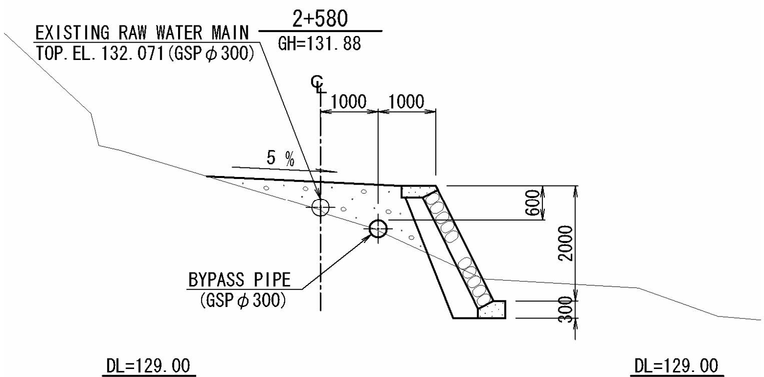


Figure 2-2.7 Typical Section of No.11 Rehabilitation Plan

① Plan for Revetment and Riverbed Protection

The wet masonry revetment with the slope of 1: 0.5 and 0.3m in depth is selected for the low water channel based on the velocity of 4.04m/sec at the control discharge. The height of the revetment is principally set at 1.7m taking into account the water depth of low water channel at the time of control discharge although it is actually varied in accordance with the pipe elevation. The pipe is buried with coverage of 0.6m as the minimum to protect from falling rocks.

Although the water level in the design flood is estimated at higher than the revetment of the low water channel, the flood channel will be covered by the mixture of sand and gravel available in the site, as the velocity of the flood channel at the design flood is estimated at 1.86m/sec.

In addition, the groin composed of gabions remains at present in this section. At the part where the wet masonry revetment will be constructed on the gabion, it will be replaced with the plain concrete foundation of the revetment to secure enough strength taking into account the velocity at the section.

(3) Structure No.12: Comoro River Right Bank Steep Slope Road Section （Sta.7 + 000 ～ Sta.7 + 100）

① Plane Alignment of the Road

Road class is categorized to the 3-5 grade of local road in the road standard of Japan based on the slight daily traffic of less than 100 numbers. Accordingly, a radius of the road curve shall be designed at more than 20m. However, existing curve radii at this section are ranging from 20m to 100m. Then the radii of the road shall remain same as existing ones.

② Cross Sectional Shape of Road

Width of the existing road is ranging from 1.5m to 5.0m approximately. The extremely narrowed width has been formed by the earth falling at the river side shoulder of the road. Then the road is to be improved to have 4.0m in width as the same structure as the access road to the Bemos WTP taking into consideration the existing condition.

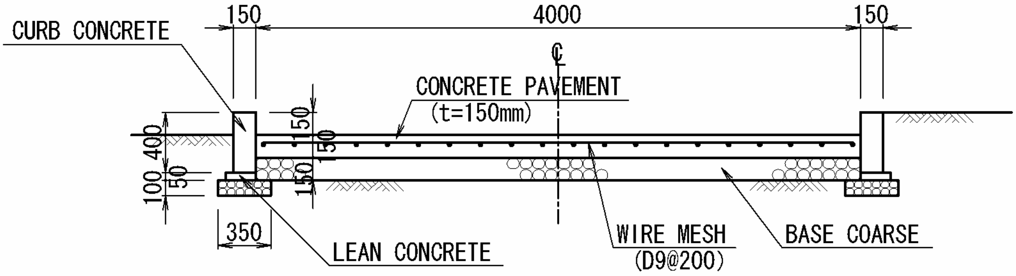


Fig. 2-2.8 Typical Section of Road

③ Vertical Alignment of Road

The maximum longitudinal slope of the existing road is as steep as 43.3%. Short length of only 6m of the section barely makes passage of vehicles possible. Taking into consideration such condition of the existing road, the maximum longitudinal slope is to be improved to 20% which is gentler than that of the access road to the Bemos WTP (the maximum longitudinal slope: 24.7%, length of the section: 15m).

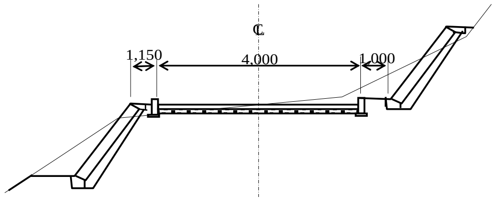
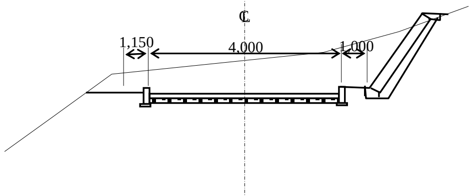
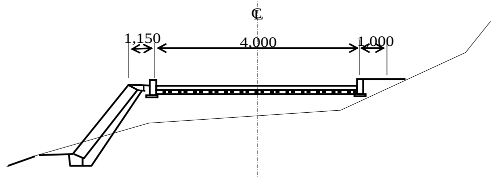
As the methods to improve the longitudinal slope, the comparison among the three methods, i.e. 1) Plan A: existing, 2) Plan B: excavation, 3) Plan C: embankment, is shown in the table 2-2.21. As the comparison result, Plan B: excavation method (the maximum longitudinal slope: 19.5%) is selected based on the following reasons.

1) Plan A: the existing longitudinal slope of 43.3% is too steep to apply to new road.
2) Plan B: traveling performance for vehicle becomes better due to the maximum longitudinal slope improvement to 19.5% which is the same with Plan C.
3) Plan C: the larger sizes of the incidental facilities are required than those of Plan B, causing less construction ability and higher cost.

④ Protection of Raw Water Main

The road alignment is designed in order that the existing raw water main is located at the road side on the hill side of the road. Accordingly, supporting the pipe by concrete supporting saddles at the hill side of the road is selected for the basic protection method of the raw water main.

Table 2.2-21 Comparison of the Longitudinal Sloping Method for Access Road

Items	Plan A：Existing Slope（Max.：43.3%）	Plan B：Excavation（Max.：19.5%）	Plan C：Embankment（Max.：19.3%）
Typical Road Cross Section			
Pavement Type	Concrete Pavement is selected due to the longitudinal slope more than 12%	Concrete Pavement is selected due to the longitudinal slope more than 12%	Concrete Pavement is selected due to the longitudinal slope more than 12%
Traveling Performance	Worst condition for traveling due to the steepest slope of 43.3%. inferior	Better condition for traveling due to rather gentle slope of 19.5% than that of access road to Bemos WTP (24.7%). good	Better condition for traveling due to rather gentle slope of 19.5% than that of access road to Bemos WTP (24.7%). good
Incidental Facilities	・Earth Retaining Works：Length 0.0m Wet Masonry 0.0m^2 ・Road side structure ：Length 66.0m Wet Masonry 217.3m^2 ・ Total： Length 66.0m Wet Masonry 217.3m^2 Small scale incidental facility is required. Best（1.00）	・Earth Retaining Works：Length 38.5m Wet Masonry 122.8m^2 ・Road side structure ：Length 56.5m Wet Masonry 176.7m^2 ・ Total： Length 95.0m Wet Masonry 299.5m^2 Rather large scaled incidental facility is required. Better（1.38）	・Earth Retaining Works：Length 38.5m Wet Masonry 90.5m^2 ・Road side structure ：Length 76.0m Wet Masonry 235.4m^2 ・ Total： Length 114.5m Wet Masonry 325.9m^2 The largest scaled incidental facility is required. Worse（1.50）
Construction Ability	Easy to construct due to small scale of earth works and incidental facilities	Rather difficult to construct due to large scale of earth works and incidental facilities	Most difficult to construct due to the largest scale of earth works and incidental facilities
Economical Efficiency（Comparison is made only on the direct cost of incidental facilities）	・Wet Masonry : 217.3×9,100 =1,977.4 (10^{3}Yen) ・Cap Conc. : 66.0×4,200 = 277.2 (10^{3}Yen) ・Base Conc. : 66.0×6,100 = 402.6 (10^{3}Yen) ・Total : 2,657.2 (10^{3}Yen) Best（1.00）	・Wet Masonry：299.5×9,100 =2,725.5 (10^{3}Yen) ・Cap Conc. : 95.0×4,200 = 399.0 (10^{3}Yen) ・Base Conc. : 95.0×6,100 = 579.5 (10^{3}Yen) ・Total : 3,704.0 (10^{3}Yen) Better（1.39）	・Wet Masonry：325.8×9,100 =2,964.8 (10^{3}Yen) ・Cap Conc. : 114.5×4,200 = 480.9 (10^{3}Yen) ・Base Conc. : 114.5×6,100 = 698.5 (10^{3}Yen) ・Total : 4,144.2 (10^{3}Yen) Worse（1.56）
Comprehensive Evaluation	Not to apply due to the worst condition of traveling.	To be applied for the road due to good condition for traveling and good economic efficiency.	Not to apply due to low efficiency of economy although good condition is obtained for traveling.

2-2-2-7 Improvement Plan of the Lower Service Reservoir and Valve Chamber in Bemos Water Treatment Plant

2-2-2-7-1 Water Distribution Plan from Bemos Water Treatment Plant

(1) Distribution Area

Water supply service area in Dili city is divided into Zone 1 to 10 as shown on Fig.2-2.9 and distribution area of Bemos water treatment plant is Zone 3. While, the terminal of Bemos Raw Water Main flows into Dili Central Water Treatment Plant and purified water is distributed to Zone 4.

(2) Distribution Amount

The government of Timor-Leste targets 2015 as the year by which safety and sufficient water will be supplied to more than 80% of people living in the city area (The State of the Timor-Leste Economy, March 2006). On the ground of provisional calculations shown on the Table 2-2.22 considering population growth rate, coverage, basic unit, efficacy rate, load factor, and time factor, water supply from Bemos Water Treatment Plant is planned to have the maximum daily amount of 2,000m^3.

Table 2-2.22 Distribution from Bemos Treatment Plant

Item		2006	2015
Distribution Area		Zone3	Zone3
Population	①	5,730persons(1)	8,889persons(2)
Population Growth Rate		5.0%(3)	5.0%(3)
Coverage of Water Supply	②	87%(4)	90%(5)
Water supplied Population	③＝①×②	4,985persons(6)	8,000persons
Basic Unit of Water Use	④	85 lpcd(7)	95 lpcd(8)
Domestic Water	⑤＝③×④	424m^3/day	760 m^3/day
Other Water Use	⑥	127 m^3/day(9)	304 m^3/day(10)
(Sub-total)	⑦＝⑤＋⑥	551 m^3/day	1,064 m^3/day
Efficacy Rate	⑧	36%(11)	65%(12)
Average Daily Water Demand	⑨＝⑦÷⑧	1,531 m^3/day	1,637 m^3/day
Daily Load Factor	⑩	83%(13)	83%(13)
Maximum Daily Water Demand	⑪＝⑨÷⑩	1,845 m^3/day	1,972 m^3/day
Time Factor	⑫	1.5(14)	1.5(14)
Maximum Hourly Distribution	⑬=⑪÷24×⑫	115 m^3/hour	123 m^3/hour

(1) (4): Project Preparation Technical Assistance: Dili Urban Water Supply Project, September 2007, ADB TA 4646-TIM

(2): assuming that population growth rate is 5.0% (3): Sector Investment Plan, 1996

(4): including unregistered water tap

(5) (12): estimate value after completion of the improvement projects for feeding pipes and distribution pipes in Dili city sponsored by ADB and others

(6) (11) (13): Preliminary Study of Human Development Project for Waterworks in Timor-Leste
(7) (8): estimated from water used amount in 2004 (80lpcd, Annual Action Plan)
(9): assuming as 30% of domestic water use amount (10): assuming as 40% of domestic water use amount
(14): estimation from population scale

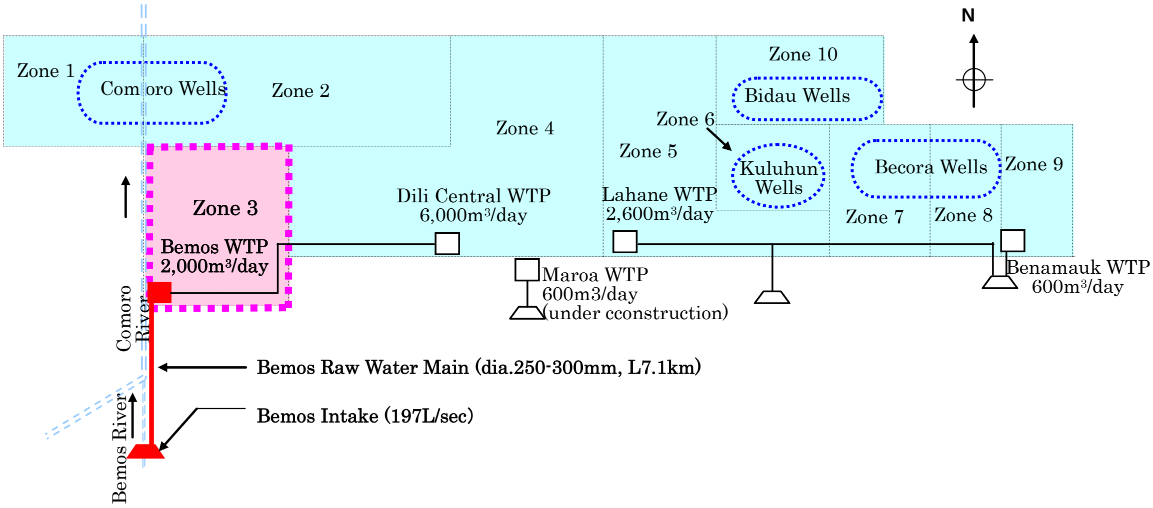


Fig. 2-2.9 Distribution Zone of Dili Water Supply

(3) Water Pressure / Water Quality

Distribution system from Bemos Water Treatment Plant to Zone 3 in Dili city is gravity flow and the planned system will follow the existing manner considering terrain of area and difference of elevations. Because of leakage from water distribution pipes and water supplying pipes, feed water pressure in Zone 3 is not sufficient for daily use. Generally water usage decreases in night time and ineffective distribution in nighttime increases compared to daytime comparetively. In order to save the operating cost, Bemos water treatment plant suspends night distribution at present and planned distribution time will be 15.5 hours per day from 6:30 AM to 10:00 PM similar to the current condition until the improvement of pipe network in Zone 3 will be completed as expected.

DNSAS Technical Guideline No.4: Water Quality provides that distributed water quality in Timor-Leste should conform to “Guidelines for drinking-water quality, World Health Organization (WHO)”. The following items shown on Table 2.23 (Total Dissolved Solid, Turbidity, Nitrate-nitrogen, Nitrite-nitrogen, Iron, Fluoride, Manganese, Escherichia coli) are examined practically at the laboratory in Water Quality Analysis Division, Dili Water and Sanitation Department, DNSAS and the distributed water is planned to meet those standards.

Table 2-2.23 Distribution Water Quality from Bemos Water Treatment Plant

TDS	Turbidity	NO_3^-	NO_2^-	Fe	F	Mn	E.Coli
1,000mg/L	5NTU	50mg/L	3mg/L	0.3mg/L	1.5mg/L	0.4mg/L	Not Detectable

* WHO Drinking Water Guideline

2-2-2-7-2 Service Reservoir to be Improved

(1) Structures to be Improved

There are two service reservoirs in Bemos Water Treatment Plant namely the Upper Service Reservoir and the Lower Service Reservoir, and each reservoir is provided with valve chamber at the outflow side. Present conditions of those structures are as shown on Table 2-2.24. The Upper Service Reservoir is in use with no detectable leakage at present conditions and is able to be used continuously as it is.

On the other hand the Lower Service Reservoir and attached valve chamber will be rebuilt. Those are being used now but so much deteriorated that they may not be safe or stable for use in the future. Considerable deformations are seen on the walls of the reservoir and leakage exudes from the walls. Concrete flakes fell and rebar is exposed at many parts on the downside of top plate and it has danger of caving or collapse. Table2-2.25 shows the evaluation results on the renovation of the Lower Service Reservoir based on Guideline on Renovation of Waterworks.

Table 2-2.24 Conditions of Service Reservoir in Bemos Water Treatment Plant

	Upper Service Reservoir	Valve Chamber of the Upper Service Reservoir	Lower Service Reservoir	Valve Chamber of the Lower Service Reservoir
Line	divided Raw water flows in	flow out to the Lower Service Reservoir	Purified water flows in from Filter	Distribution to Dili city
Structure	set on the ground	Shed and Basement	Semi-Subterranean	Shed on the spot excavation
Capacity	1,000 m^3	—	500 m^3	—
Construction year	1993	1993	1982	1982
Visible Conditions	Repair mark, Slight cracks (wall)	No serious deformation	Serious deformation, Long crack (wall), Concrete falling, Exposed rebar (roof, beam, column)	Concrete falling, Exposed rebar, Broken rebar (roof), Serious crack (beam)
Water tightness	no leakage detected	—	Leakage through wall	—
Judgment	Possible for continue utilization	Possible for continue utilization	Renovation is required	Renovation is required

Table 2-2.25 Physical Evaluation of the Lower Service Reservoir and Valve Chamber

	Walls	Upper Slab	Valve Chamber
Secular Distortion	26years has passed. Many leakage repair marks are on the walls. Walls deforms 4-7cm from datum plane. Long crack of width 2-6mm appears.	26years has passed. Concrete falls widely at many parts. Rebar are exposed and rusty.	26years has passed. Concrete falls widely at many parts. Rebar are exposed, rusty, and broken. Deep and wide cracks appear on the beams.
Neutralization	Neutralization has been advancing more than 1cm from the outside surface.	Neutralization has been advancing more than 6cm and reached to rebar.	Neutralization has been advancing more than 6cm and reached to rebar.
Compressive Strength	As the results of concrete compressive strength test with Schmidt hammer, minimum value is less than $18N/mm^2$ and durability of the concrete construction has decreased.		
Leakage	As a result of leakage test, water level decreased by 2cm in an hour.	Rain or drain water through roof slab is not detected.	Leakage through wall was detected during leakage test.
General Findings*	Prompt rebuilding is required.	Prompt rebuilding is required.	Prompt rebuilding is required.

Note: General Findings are the evaluation results on the renovation of the Lower Service Reservoir and Valve Chamber based on Guideline on Renovation of Waterworks (Japan Water Works Association).

2-2-2-7-3 Layout and Structure of the Lower Service Reservoir

(1) Layout

Compound of Bemos Water Treatment Plant is the leveled land cut out from the steep slope. The Lower Service Reservoir is a semi subterranean structure and its top is exposed over the ground surface. Valve chamber is attached on the north wall of the reservoir and outside of the chamber is excavated. The upper and middle of cut slope is retained with masonry and the lower has concrete retaining wall. The Upper Service Reservoir is on the east side of the Lower Service Reservoir and purification unit is on the south side. There is no level ground for a new construction in the compound and long chlorination piping is not preferable. Therefore, the new Lower Service Reservoir is planned to be located on the same place as the semi subterranean structure after the demolition of the existing reservoir.

(2) Foundation Ground

Outcrops of gneiss are exposed on the hillside of the Upper Service Reservoir. Lithological character on the site is hard but easy to flake. The Lower Service Reservoir is set on the foundation of rock and rudaceous soil cut down from the existing ground. There is no visible sign of subsidence on the floor concrete of the reservoir. The foundation of the existing reservoir is considered as stable enough for the new construction.

(3) Conditions for Construction

Earth retaining works for a new reservoir is necessary on the east side of the Lower Service Reservoir (hillside: A – A line on Fig. 2-2.11) and the south side (plant side: B – B line on Fig. 2-2.11) as caused by demolishing the existing Lower Service Reservoir. Top plate of the existing reservoir bears horizontal load of earth pressure and when it is removed some kind of support is required. Walls on the hillside and the plant side of the existing reservoir will be left as they are then anchor bolts will be set on each left wall. Floor plate of the existing reservoir will be also left and used for the supporting point of anchoring work. New reservoir will be set inside the left walls and floor plate and this has advantage in view of the reduction of removal cost and industrial waste.

(4) Shape / Structure / Scale

① Shape / Structure

Considering that the object of this project is in improvement of waterworks, it is planned that the effective capacity of the new Lower Service Reservoir is 500 m^3. This value is the same as the capacity of the existing reservoir and equivalent of maximum water supply for 6 hours. For the reasons that the shape of the existing Lower Service Reservoir is rectangular and the new reservoir will be set on the same place, new reservoir is designed as a rectangle solid of reinforced concrete construction. Circular cylinder shaped concrete tank of this scale has less advantage in workability. Following the present form of the inside reservoir, new reservoir will be divided into two chambers setting the center wall so that cleaning and maintenance of one chamber is possible using the other half side, and also diverting walls will be set in the chamber to avoid flow stagnation.

② Water Level / Elevation

At detail design stage, bench mark survey was carried out based national bench mark. Therefore, elevation on detail design is + 1.1m compare with basic design. According to elevation on detail design, water level and elevation of the main position of the Lower Service Reservoir are as follows;

- Floor level : = Floor level of existing reservoir + leveling concrete + floor plate
  = EL. 86.55m + 0.05m + 0.35m
  = EL. 86.95m

- Low Water Level : = Floor level of planned reservoir + allowance 0.15m *
  = EL. 86.95m + 0.15m
  = L.W.L. 86.00m

- Center of outflow pipe : = L.W.L. － double diameter of outflow pipe *
  = L.W.L. 86.00m － 2×0.25m
  = L.W.L. 85.50m

- Top of the upper slab : = center of outflow pipe from Filter － bend pipe － allowance
  = L.W.L. 91.125m － 0.5m － 0.325m
  = EL. 90.30m

- High Water Level : = Top of the upper slab － top plate － allowance 0.3m *
  = EL.90.30m － 0.20m － 0.30m

= H.W.L. 89.80m

* Design Criteria on Waterworks (2000), Japan Water Works Association

③ Dimensions of Structure

Inner dimensions of the existing reservoir are 14.3m in length (direction from inflow to outflow), 13.3m in width, and 2.9m in height. New reservoir is designed as same length of the existing one because of the facilities layout. The height is decided by the water level of outflow pipe from filter. The width is calculated from the planned effective capacity, the length, and the height.

Dimensions of the Lower Service Reservoir are as follows;

- Inner Length：
  = outside length of existing reservoir－wall of existing reservoir －allowance－wall of planned reservoir
  = 13.76m － 0.26m － 0.25m － 2×0.35m
  = 12.55m
- Effective Length：
  = inner length－diverting plate
  = 12.55m － 3×0.25m = 11.80m
  = 4×2.95m
- Structure Length：
  = effective inner length + diverting plate + wall thickness
  = 11.80m + 3×0.25m + 2×0.35m = 13.25m
- Inner Height：
  = (top of the upper slab - top plate) - Floor level
  =(EL. 90.30m - 0.20m) - EL. 86.95m
  = 3.15m
- Effective Depth：
  = High Water Level - Low Water Level
  = H.W.L. 88.70m - L.W.L. 86.00m
  = 2.70m
- Structure Length：
  = (top of the upper slab - top plate) - Floor level
  = EL. 90.30m – (EL.86.95m – 0.35m) = 3.70m
- Effective Width：
  = （Effective Capacity + diverting wall） ÷（Inner length × Effective Depth）
  = （500m^3 ＋ 5.20m×0.25m×2.70m×6plates）÷（12.55m×2.70m）
  = 15.45 ≒ 15.60m
  = 2×7.80m
- Inner Width：
  = Effective Width + dividing wall
  = 15.60m + 0.25m
  = 15.85m
- Structure Width ：
  = effective width + diverting plate + wall thickness
  = 15.60m + 0.25m + 2×0.35m = 16.55m

Table 2-2.26　Planned data of the Lower Service Reservoir

Dimension	Water Level	Foundation	Infrastructure
W: 16.55m L: 13.25m H: 3.70m Rectangular tank	H.W.L.: +89.8m L.W.L: +87.1m Effective Depth : 2.70m Effective Capacity : 500 m³	Outcrop of gneiss is exposed at hillside and the existing reservoir is located on the stable foundation ground. Floor plate of the existing reservoir will not be removed and the planned reservoir will set on the existing floor.	Electricity and Water are supplied at the site of planned reservoir. Road to reservoir is mostly paved.

④ Design Modification at Detail Design Stage in the Present Project

Design modifications regarding lower service reservoir are as follows;

- Elevation of floor of valve chamber lower 0.1m.
- Location of step moves to east side of valve chamber from existing location
- Protection wall type change wet masonry to concrete retaining wall

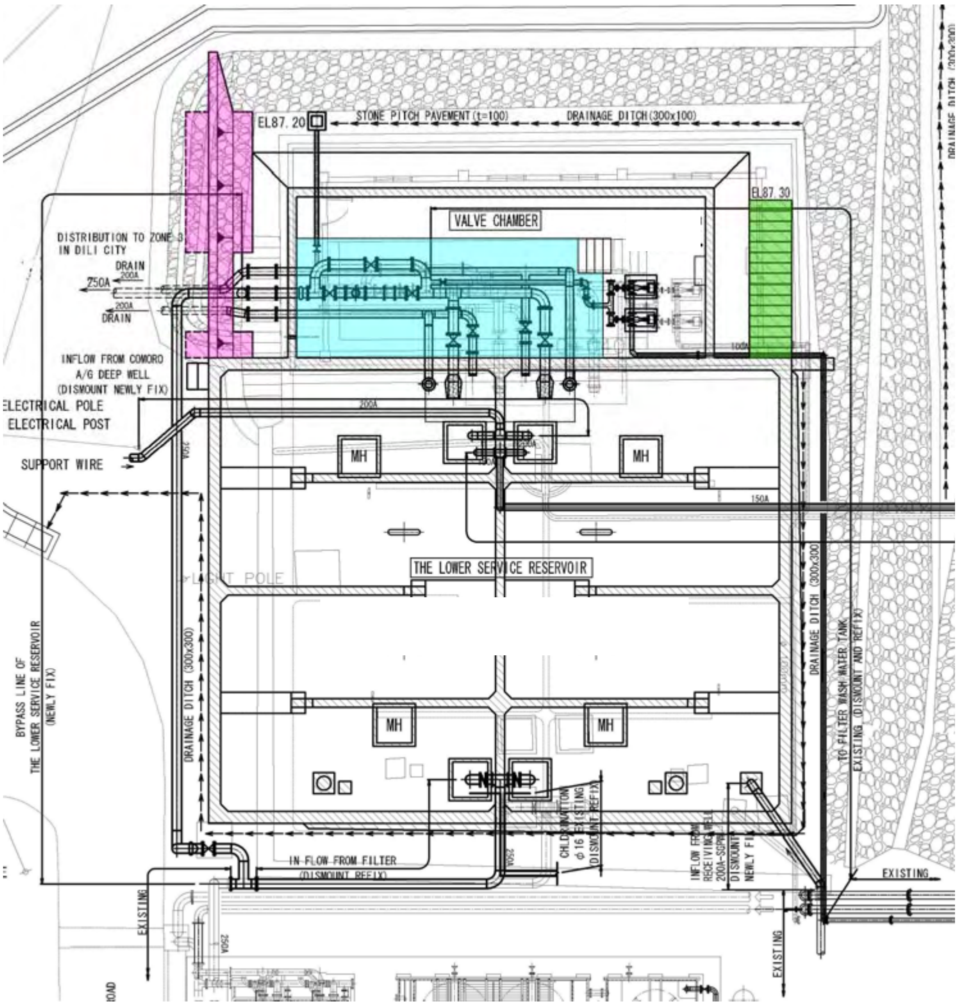


Figure 2-2.10　Design Modification at Detail Design Stage

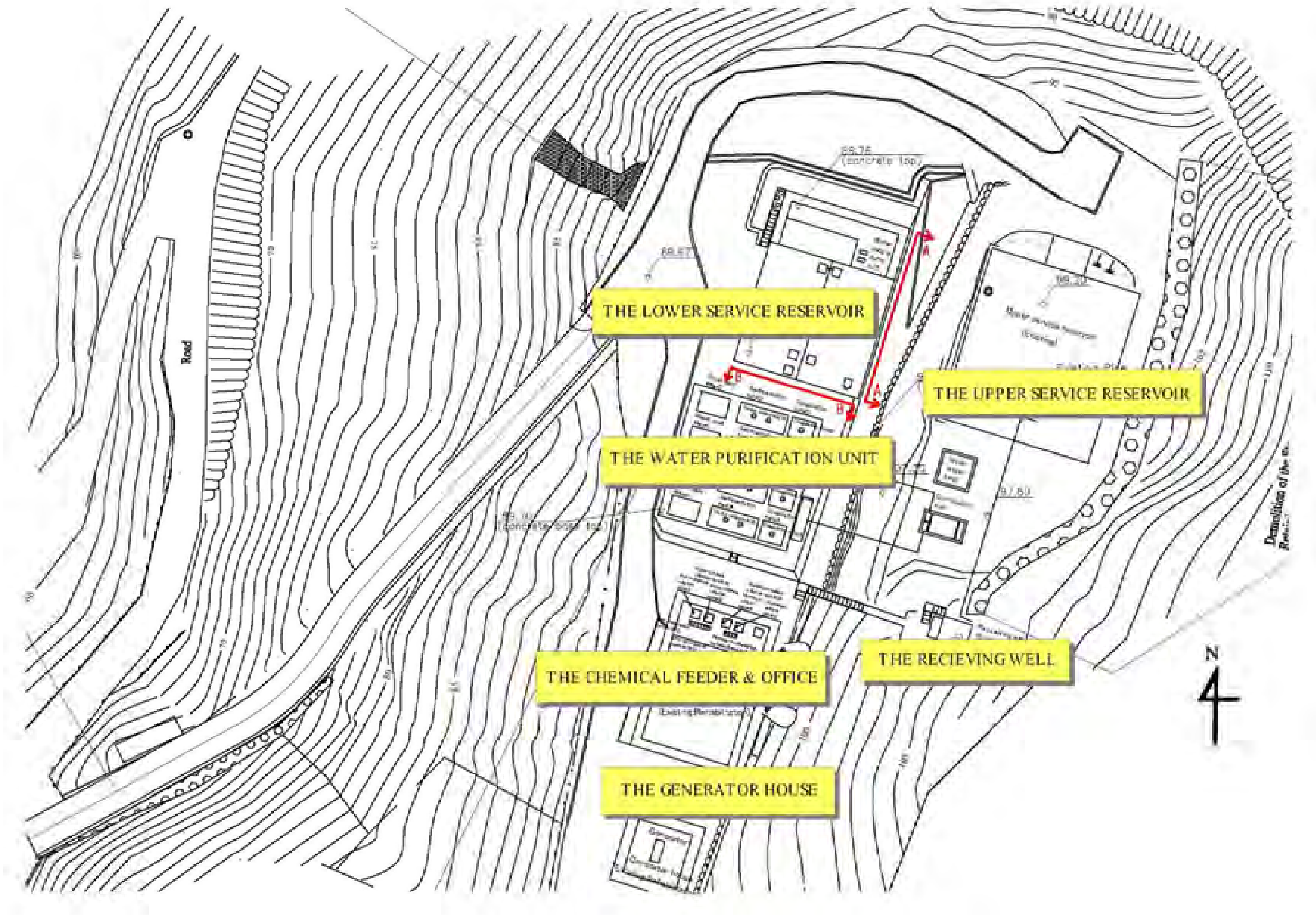
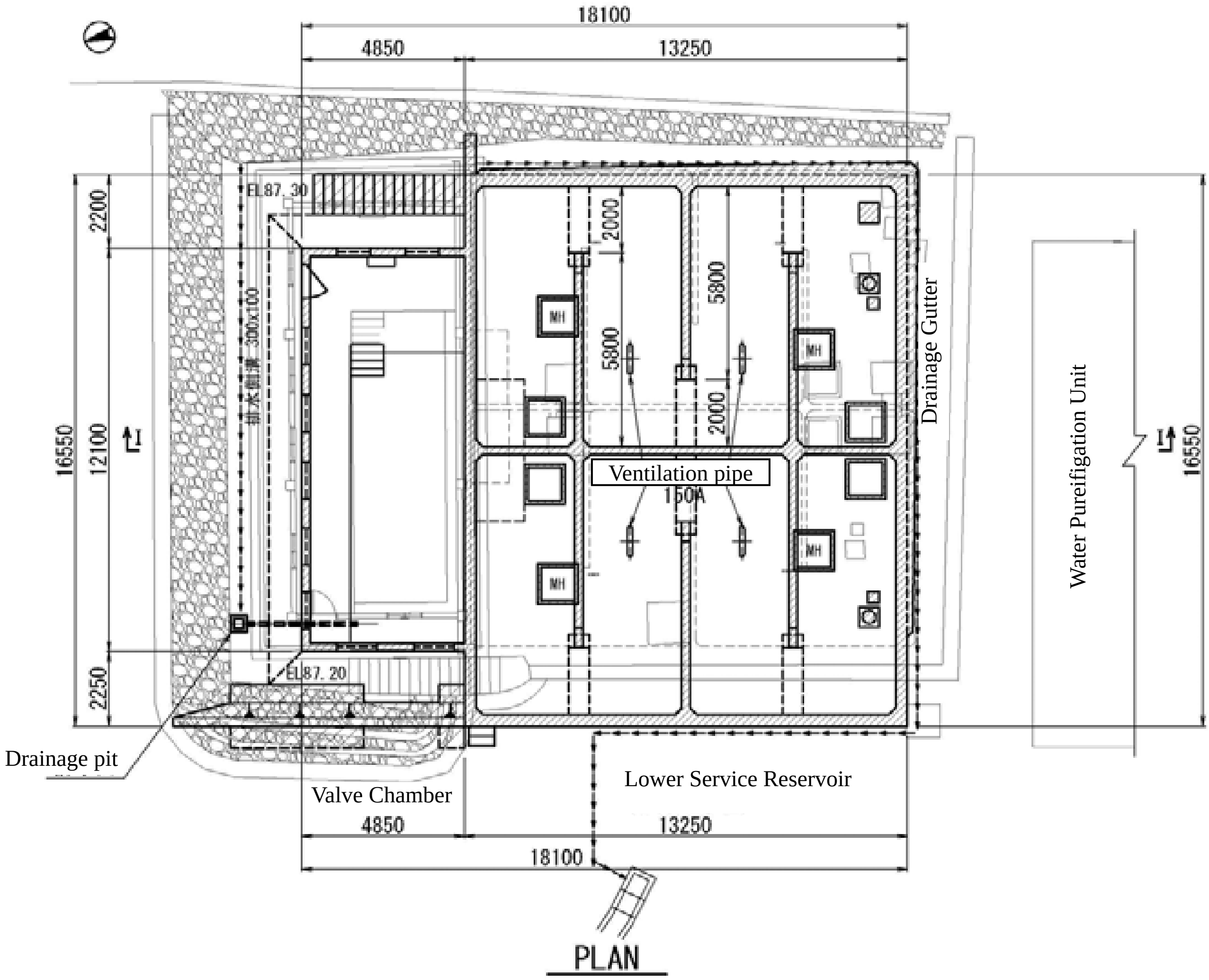


Fig. 2-2.11 Layout of Bemos Water Treatment Plant



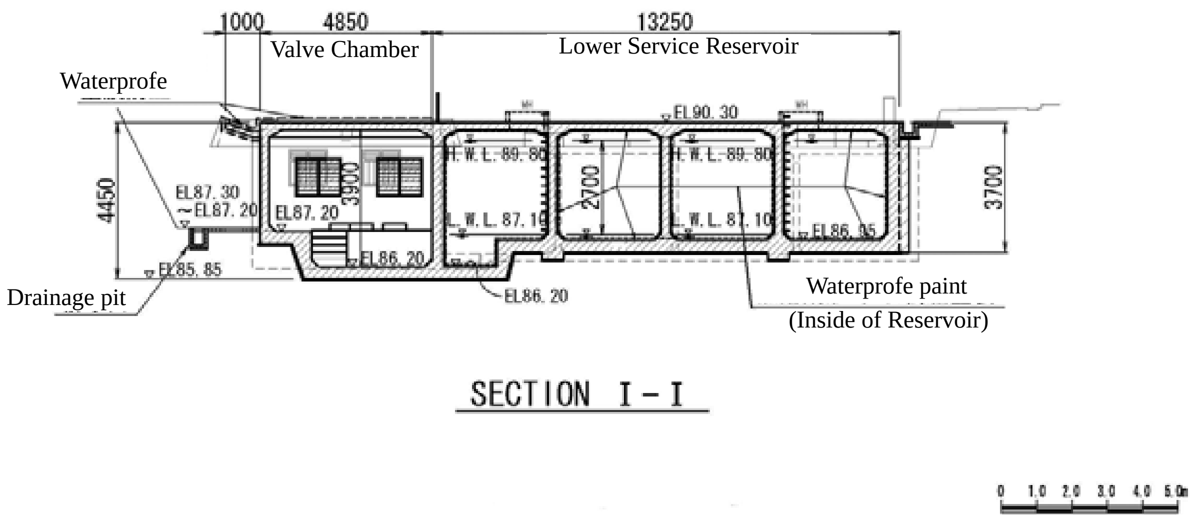


Figure 2-2.12 Basic Plan of Lower Service Reservoir

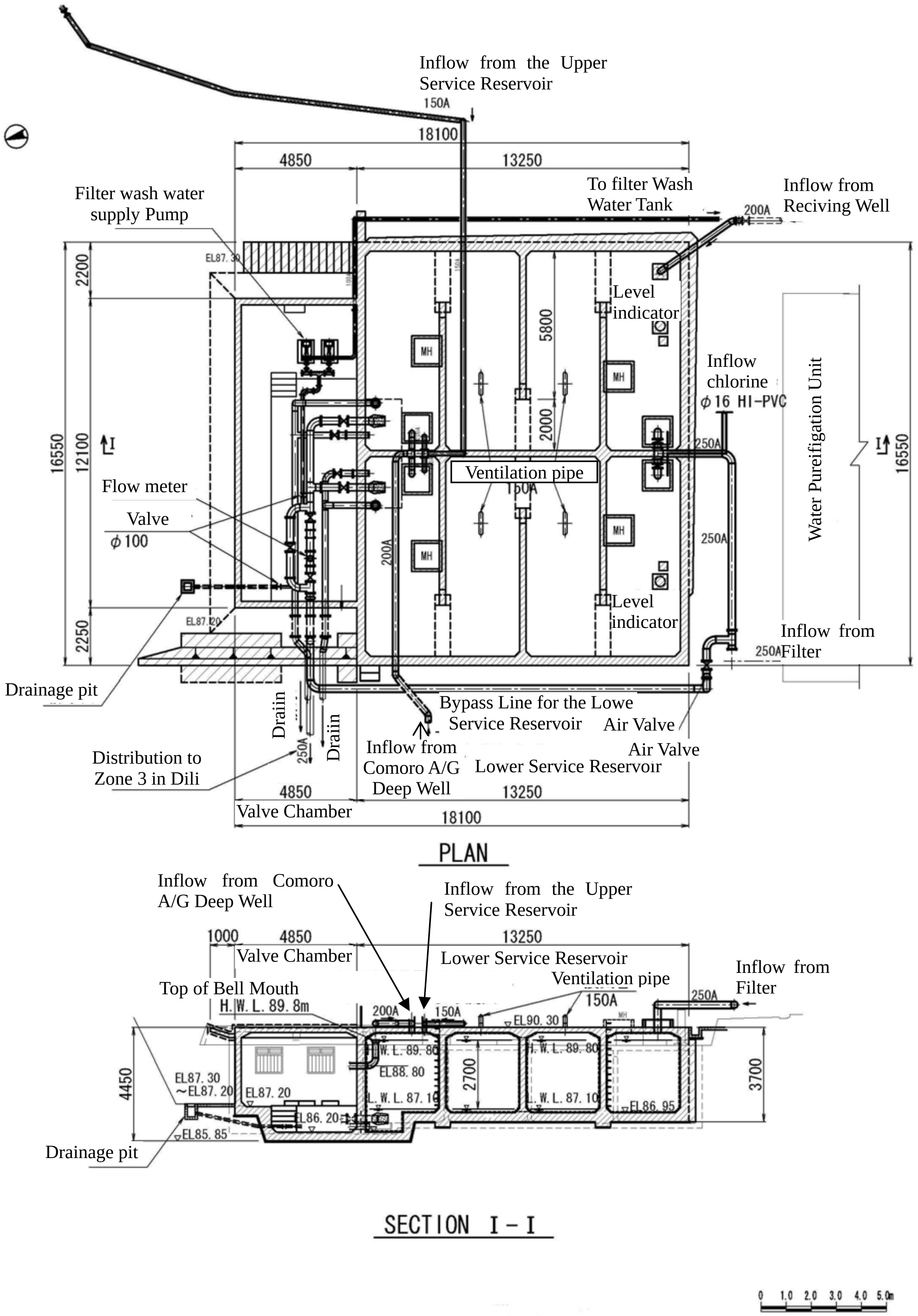


Figure 2-2.13 Pipe Arrangement of Lower Service Reservoir

⑤ Materials / Construction Method

Planned materials and construction method for the Lower Service Reservoir are as follows.

Table 2-2.27 Materials and Construction Method for the Lower Service Reservoir

Works	Existing Method	Planned Method	Basis
Reservoir			
Foundation	Mat foundation	Mat foundation	the same as the existing construction
Wall	Reinforced concrete	Reinforced concrete	generally applied to civil construction
Finishing (outside)	Paint (partially)	As-cast concrete	generally applied to civil construction
Finishing (inside)	Waterproof mortar	Water-resistant coating	complying with design criteria*
Top plate	Reinforced concrete	Reinforced concrete	generally applied to civil construction
Finishing (roof)	Waterproof mortar	Asphalt waterproof	generally applied in the area
Valve Chamber			
Foundation	Mat foundation	Mat foundation	the same as the existing construction
Wall	Reinforced concrete	Reinforced concrete	generally applied to civil construction
Finishing (outside)	Paint (partially)	As-cast concrete	generally applied to civil construction
Finishing (inside)	Waterproof mortar	As-cast concrete	generally applied to civil construction
Roof	Reinforced concrete	Reinforced concrete	generally applied to civil construction
Finishing (roof)	Waterproof mortar	Asphalt waterproof	generally applied in the area

* Design Criteria on Waterworks (2000), Japan Water Works Association

2-2-2-7-4 Pipe Arrangement and Operation

(1) Piping System

Comparatively new equipments attached on the Lower Service Reservoir which were installed in 2007 at the same time with the renewal of purification unit in Bemos Water Treatment Plant such as inflow line, chlorination line, level gauges, flow integrator, water supply pumps, and those pipes and cables will be reused. They will be once dismantled and removed during the demolition of the reservoir, then temporally kept at store and reinstalled after the new construction. Other aging piping set installed by Indonesian government in the 1980’s are rusty and valves have difficulty in open-close operation. Those will be replaced with new equipments.

Following the present system of the reservoir, outflow pipe, overflow, drain pipe will be set on the outflow side. Bypass pipe connecting filter outflow and reservoir outflow will be newly laid in preparation of the accident or total maintenance. Sluice valve and air valve will be set in this line. Manholes for cleaning and maintenance of inside reservoir will be equipped at inflow side and outflow side on the top plate. Ladder will be embedded on inside wall under the manhole and air vent will be set up on the top plate.

Table 2-2.28 Pipe Arrangement Connected to the Lower Service Reservoir

Line / Instrument / Equipment	Diameter	Number / Shape / Coping
Inflow from Filter Ⓐ from the Upper Service Reservoir Ⓑ from Comoro A/G Well (backup) Ⓒ Bypass of Purification Unit Ⓓ	 GSP ϕ 250mm GSP ϕ 150mm GSP ϕ 200mm GSP ϕ 200mm	 1line (dividing into 2chambers, reuse) 1line (dividing into 2chambers, renewal) 1line (dividing into 2chambers, renewal) 1line (into hillside chamber, renewal)
Outflow Ⓔ	GSP ϕ 250mm	2lines (screen is fixed, renewal)
Overflow	GSP ϕ 200mm	2lines (bell mouth is fixed, renewal)
Drain	GSP ϕ 200mm	2lines (renewal)
Bypass of the Lower Service Reservoir Ⓕ	GSP ϕ 250mm	1line (new line)
Chlorination	PVC ϕ 16mm	2lines (reuse)
Level Gauge (with pole and transmitter)		2sets (pressure detector, reuse)
Flow Integrator	ϕ 250mm	1unit (axial turbine, reuse)
Water Supply Pump (with control panel)		2units (centrifugal pump, reuse)
Air Vent	GSP ϕ 100m	4pieces (renewal)
Manhole	1.0m×1.0m	4units (renewal)

* Refer to Fig. 2-2.14 for Ⓐ−Ⓕ,

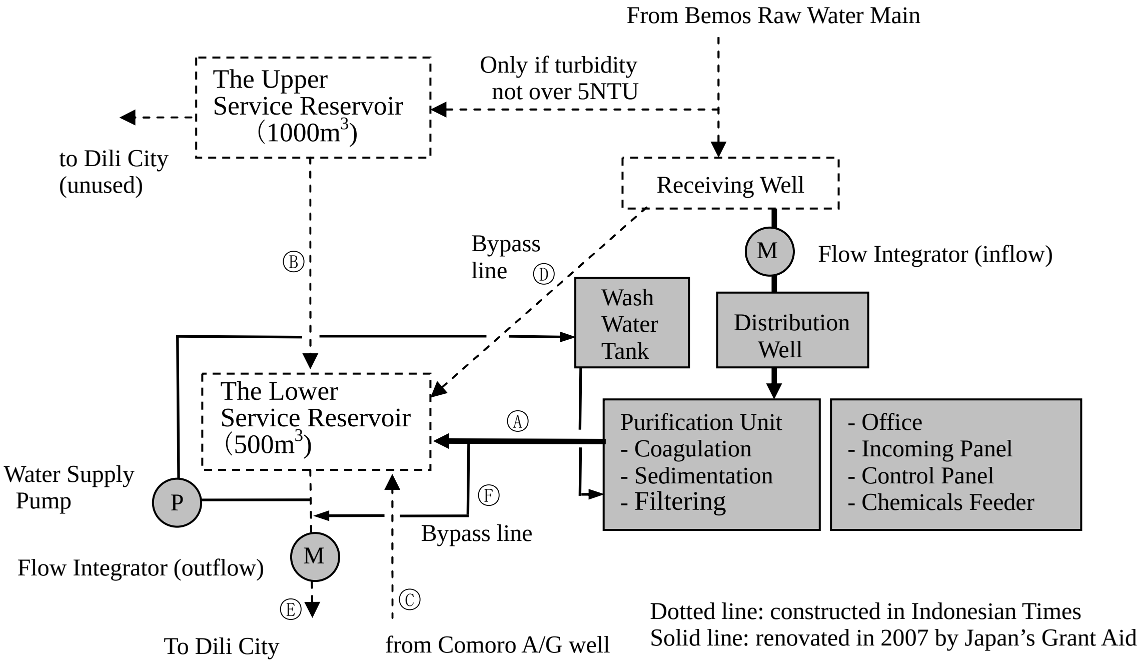


Fig. 2-2.14 Piping System in Bemos Water Treatment Plant

(2) Operation of the Lower Service Reservoir

Planned inflow line and valve layout are the same as the existing system. Inflow lines from Filter, the Upper Service Reservoir, and Comoro A/G well will be divided into each chamber of the Lower Service Reservoir. Bypass line from receiving well will be connected to hillside chamber. End of inflow lines will be higher than high water level of the reservoir. The Upper Service Reservoir will be used in combination with the Lower Service Reservoir during the time that turbidity of raw water is less than 5NTU. In the event of periodical maintenance service inside the Lower Service Reservoir, one chamber is emptied out and another chamber is used. Bypass pipe from filter to distribution line to the city will be used in case of accident or total repair.

Table 2-2.29　Operation of the Lower Service Reservoir

Conditions	Line Operation
Normal	Inflow from Filter Ⓐ
Turbidity of Raw Water is not over 5NTU	Inflow from the Upper Service Reservoir and Filter Ⓐ, Ⓑ
Turbidity of Raw Water is high (500NTU)	Suspended Inflow to whole Water Treatment Plant
Cleaning/Maintenance of Purification Unit	Inflow from the Upper Service Reservoir or Bypass pipe of Purification Unit Ⓑ/Ⓓ
Cleaning/Maintenance for 1 chamber of the Lower Service Reservoir	Inflow from Filter to another chamber of the Lower Service Reservoir Ⓐ
Cleaning/Maintenance for 2 chambers of the Lower Service Reservoir	Distribution to the city through Bypass pipe of the Lower Service Reservoir Ⓕ

* Refer to Fig. 2-2.14 for Ⓐ−Ⓕ,

Valve chamber will be set on the excavated low spot and yard drainage gathered through gutter set around valve chamber will flow into drain pipe. This connection will have sluice valve that is always opened and when drain the reservoir, the connecting valve will be closed so as not to spill out from drain outlet. Since an operator will close the connecting valve at the same time that he will open the drain valve of the reservoir in the same place, these are a set operation and not fallible.

2-2-2-8　Landslide Protection at the Access Road of Bemos Water Treatment Plant

2-2-2-8-1　Design Policy of Landslide Protection

Based on the site survey result of “Land Surface Exploration”, “Geological Investigation” and “Soil Exploration” (refer to Chapter 1. 1-2 (2) (f) Landslide at Access Road to Bemos Water Treatment Plant and Chapter 2. 2-2-1-4 ①Main factors caused the landslide and ②Inducement of Landslide) , the possible range of further landslide is studied and the protection method is proposed the protection method as the countermeasure for landslide including previous sliding range. Furthermore, the safety factor required for the Project shall be secured in the sliding protection study taking the natural condition of the Timor-Leste into account.

There is a need to take countermeasure from further landslide with safety for long period, because there is only one access road to the Bemos water treatment plant on which the landslide has been occurred.　Removal of obstruct soil on the access road is not enough to prevent further sliding. Therefore, it is required to provide more certain protection methods of landslide as follows.

① Slide soil shall be removed because the soil is reformed and reduced in strength

② Slide soil is replaced with strong and permeable (drainable) material, such as sand and gravel

③ Protect method such as piling, anchoring, retaining wall (wet masonry revetment or concrete revetment, etc.) is applied.

The following process is examined as the landslide protection.

① Consolidating the survey and test result and confirming the strength of soil of both conditions before sliding and after sliding by the sliding analyses. And further confirming the existing stability against landslide.
② Comparison study among the protection methods will be made and then proposed one will be selected for the Project.
③ Stability of the slope after protection is studied and confirmed. Then, the basic design of the protection is made.

2-2-2-8-2 Estimation of Soil Strength before Landslide

The longitudinal cross section is presumed by the cross survey result at the both side profiles of the slid block. Applying this longitudinal cross section to the circular slip analysis method, slope stability and strength of soil before sliding is estimated.

(1) Safety factor before sliding

Based on the “Manual for River Works (Draft)” and “Planning and Design Standard of Land Improvement Project, Landslide Protection for Agricultural Land”, the safety factor before sliding (Fsn) is recommended as follows. Then, the Fsn = 0.98 (at the heavy rains) is selected for the Project.

① In case that there are some unusual condition, change and sigh of collapse on the slope ：Fsn = 0.95
② In case that there is no sigh of immediate collapse on the slope：Fsn = 1.00

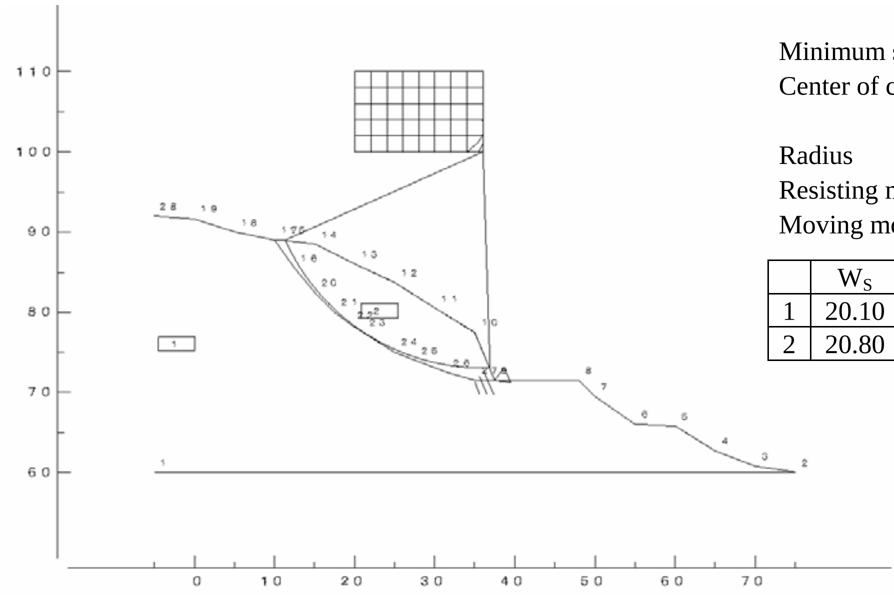
(2) Strength Parameter of Soil before Landsliding

Soil strength parameter for the stability analysis is determined by the results of soil test and reversal calculation method.

① Angle of internal friction of soil : the value of φ’ is estimated by the reversal calculation method applying the safety factor before sliding at Fsn = 0.98.
② Weight of unit volume of slided soil is determined as [moistured]18.5 kN/m^3、[suturaterd] 20.1 kN/m^3 based on the soil test result.

(3) Slope Stability and Calculation Result of Stability Analysis before Landsliding

The longitudinal cross section of slope before sliding assumed by the land shape of neighboring slope is applied to the stability analysis using soil cohesion at C = 0 kN/m^2 . Angle of internal friction of soil φ is estimated at φ=26.5°when the safety factor is secured at Fsn=0.98.



Minimum safety	Fs_{MIN}	=	0.981
Center of circle	X	=	36.00 m
	Y	=	100.00 m
Radius	R	=	27.03 m
Resisting moment	MR	=	20,171 kN・m
Moving moment	MO	=	20,569 kN・m

	W_S	W_W	φ	C	C_C	E_H	E_V
1	20.10	18.50	50.00	0.0	0.0	0.0	0.0
2	20.80	19.20	26.50	0.0	0.0	0.0	0.0

W_S: Saturated unit weight of soil
W_W: Wet unit weight of soil
φ: Soil internal friction angle
C: Soil Cohesion
C_C: Coefficient for Cohesion
E_H: horizontal seismic coefficient
E_V vertical seismic coefficient
Unit weight of water: 9.80kN/m^3

Figure 2-2.15 Stability Analysis Result: CASE 1 Slope Stability before Landslide

2-2-2-8-3 Slope Stability after Landslide

The slope stability regarding clod of landslide is confirmed by stability analysis based on soil strength parameter determined by the results of soil test and reversal calculation method.

(1) Soil strength parameter after landslide

The slope stability regarding clod of landslide is confirmed by stability analysis based on soil strength parameter determined by the results of soil test and reversal calculation method.

The result of soil test is shown as below table. Soil strength parameter of natural ground stands on the literature, because soil strength parameter by calculation based on Mackintosh penetration test is not unreliable. In case that N value of soil is over 30, it is difficult to measure correctly by Mackintosh penetration test.

Summary of Soil Test Result

Item	Soil internal friction angle		Cohesion (KN/m^2)	Unit weight (KN/m^3)	
	φ	Evidence	C	saturated	wet
Landslide clod	26.6°	Soil test result	0	20.8	19.2
	26.5°	reversal calculation method	-	-	-
Natural ground	40.0°	literature	0	20.1	18.5

Note; Soil internal friction angle

Case 1; based on result of penetration test: φ=26.6 °

φ: Soil internal friction angle φ= $\sqrt{15 \times N}$ +15

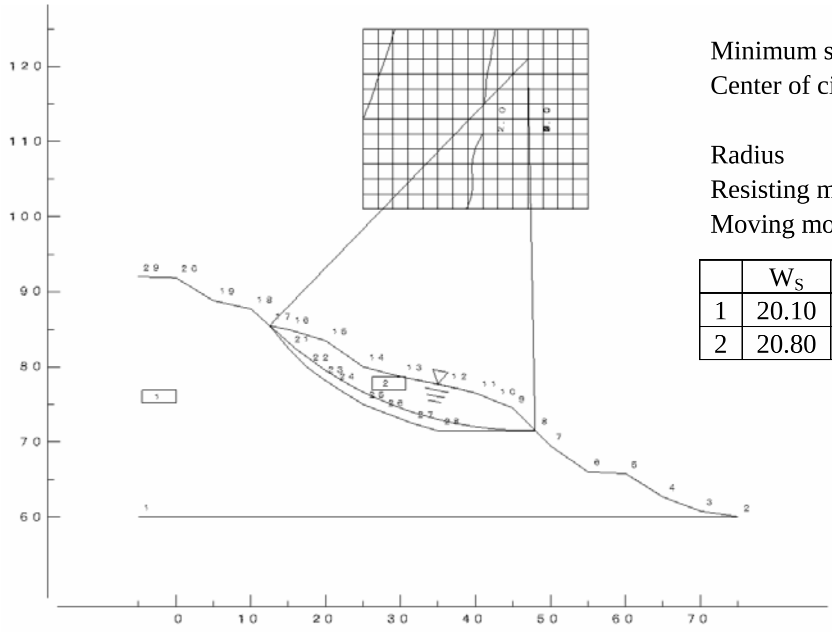
N value is nearly 9: φ= $\sqrt{15\times 9}$ +15 = 26.6°

Case 2; based on result by reversal calculation method: φ=26.5°

Both result is almost same, therefore φ=26.5°is selected as safety side for calculation

(2) Slope Stability and Calculation Result of Stability Analysis after Landslide

Based on the angle of internal friction of soil φ=26.5°, which is calculated by stability analysis when the safety factor is secured at 0.98, the result of the stability analysis after landslide is as follows. It shows that the landslide clod slope is stability, because SF = 1.437. However, if the clod on the access road is removed, landslide maybe occurs again.



Minimum safety	Fs $_{MIN}$	=	1.437
Center of circle	X	=	47.00 m
	Y	=	121.00 m
Radius	R	=	49.50 m
Resisting moment	MR	=	31,232 kN・m
Moving moment	MO	=	31,232 kN・m

	W_S	W_W	φ	C	C_C	E_H	E_V
1	20.10	18.50	50.00	0.0	0.0	0.0	0.0
2	20.80	19.20	26.50	0.0	0.0	0.0	0.0

W_S: Saturated unit weight of soil
W_W: Wet unit weight of soil
φ: Soil internal friction angle
C: Soil Cohesion
C_C: Coefficient for Cohesion
E_H: horizontal seismic coefficient
E_V vertical seismic coefficient
Unit weight of water: 9.80kN/m^3

Figure 2-2.16 Stability Analysis Result: CASE 2 Slope Stability after Landslide

2-2-2-8-4 Comparison of countermeasures for landslide

(1) Features of landslide

Based on surveying, features and corresponding methods for this landslide were organized to consider countermeasure work for the landslide.

① Sliding soil mass is soften by sliding. Soil mass become more moisturized in rainy season and it may happen another slope failure. ⇒ **Countermeasure: Removing slide soil mass**

② It is recommended to backfill with permeable material such as river bed sand and gravel or drain material after removing soil mass, and to install perforated drain pipe to drain away rainwater immediately. ⇒ **Countermeasure: Drainage of surface water and ground water.**

③ Strong structures are required at the end of sliding against soil pressure by the ground and backfill material. ⇒ **Slide check works.**

④ It is recommended to construct open type protection work on the head cliff of lateral and upper part of sliding to check progression of slope failure and to drain surface water and ground water immediately. ⇒ **Protection work on lateral slope.**

According to above, removing soil, control works to drain surface water and ground water and slide check works at the end to stabilize the slope are required. Protection work for slope around the head cliff is required.

(2) Selection criteria for countermeasure

Control works, prevention works and combined works of both can be considered.

- Control works
  Construction method to stop or mitigate landslide activity by changing natural condition such as terrain, ground water, etc..
- Prevention works
  Construction method to stop all or partial landsliding activity by deterrent force of structures.

Countermeasure for landslide is not limited to only one. The most proper measure shall be selected considering landslide mechanism, scale of block, economy and workability. Following figure shows countermeasures for landslide.

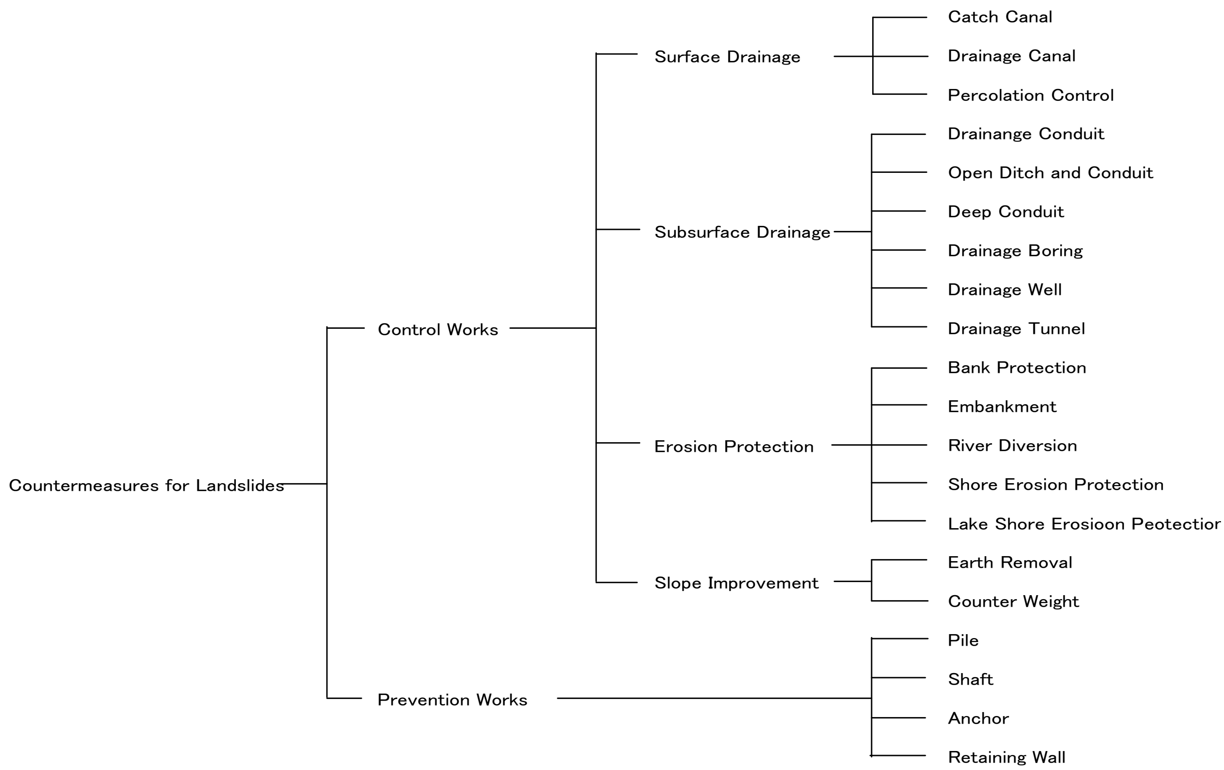


Figure 2-2.17 Countermeasures for Landslide
(Standard for Land Improvement Planning, Farmland Landslide Prevention Measures)

(3) Comparison of Countermeasurs

1) Surface drainage and deep subsurface drainage (control works)

This is a countermeasure for prevention of landslide. Surface drainage and subsurface drainage includes canal works, percolation control, drainage conduit, drainage boring and etc.

Since the landslide in the objective area occurs by concentrated downpour in rainy season, drainage of surface water and ground water in short period. However, there is a possibility of argillation of slide soil mass by rain water and perforated drain pipe drains only the water around the pipe. Therefore, these countermeasures are not proper for this area.

However, since landslide is affected by rain water and ground water, replacing sliding soil mass with permeable material and installing perforated conduit are applicable.

2) Erosion protection (control works)

Erosion protection work is effective for the case that the end of landslide reaches to a stream or a river. It is not applicable for this case.

3) Slope improvement (control works)

Slope improvement works include earth removal and counter weight. Since access road is located at the end of landslide, counter weight is not applicable.

Earth removal is a measure to stabilize the slope reducing soil load at upper part of the slope and reducing driving power on the slip surface. Generally, upper part of the landslide is removed till the required safety factor is obtained. Considering the necessity of drainage of rain water and ground water in a short period, it is recommended to replace sliding soil mass with permeable material.

4) Prevention works

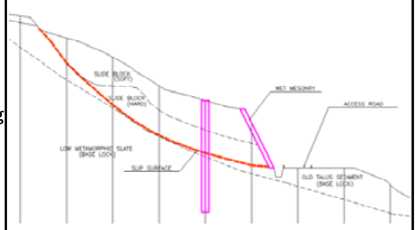
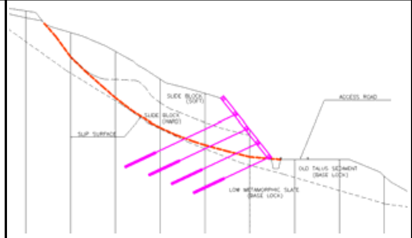
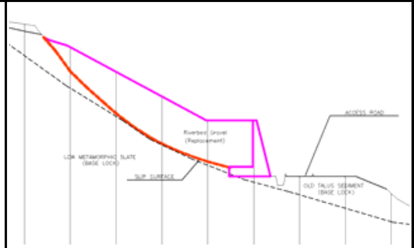
Prevention works for collapse of the end of landslide include pile work, anchor work and retaining wall. As the result of comparison, retaining wall is applicable (Table 2-2.30).

(4) Adopted Countermeasure

As the result of examination described above, following countermeasures are adopted.

- Slope improvement work by replacing sliding soil mass with quality permeable material (Earth removal)
- Prevention work to hold replaced filling material (retaining wall).

Table 2-2.30 The Result of Comparison of Prevention Works

Type	Compatibility Condition	Merit	Demerit	Diagram	Compatibility to This Landslide	Evaluation
Pile Work	・Slip surface is comparatively shallow and strength of foundation is large. ・Sliding soil mass is not extremely soft ・Transportation of material is possible	・Immediate and direct effect ・Easy calculation of exoected effect ・A lot of construction results	・Small effect for deep landslide ・Flow area of groud water is reduced sometimes ・Water supply during drilling may affect to landslide ・High cost ・Comparatively large scale of temporary facility		・Remaining fear factor of sliding soil mass and clay fraction ・Drainage of ground water in the sliding soil mass may be limited by reducing flow area of ground water ・Uneconomical due to high cost and large scale of temporary facility	×
Anchor Work	・The foundation to fix anchor is shallow	・General as countermeasure for landslide ・Immediate and direct effect ・Easy calculation of expected effect ・Work on a rapid slope is possible	・Reaction wall is required ・High cost ・Comparatively large scale of temporary facility		・Remaining fear factor of sliding soil mass and clay fraction ・Sliding soil mass become soft by rain water infiltlation and it requirs a large scale reaction wall ・Uneconomical due to high cost and large scale of temporary facility	△
Concrete Retaining Wall	・The end of landslide block。 ・The foundation has enough strength.	・Effective for collapse at the end of landslide block ・Possible to hold slope deformation ・Easy construction ・Certain holding of sliding	・A large scale is required to meet to soil and water pressure ・Intimidating high wall		・Remaining fear factor of sliding soil mass and clay fraction ・Sliding soil mass become soft by rain water infiltlation and it requirs a large scale reaction wall ・Simple structure and easy construction ・Local material can be utilized	△
Concrete Retaining Wall + Earth Removal・Replacing	・The end of landslide block。 ・The foundation has enough strength.	・Effective for collapse at the end of landslide block ・Possible to hold slope deformation ・Easy construction ・The most certain holding of sliding ・Removing fear factor by removing sliding soil mass, securing permeability by replacing	・A large scale is required to meet to direct soil pressure by replacement material ・Intimidating high wall		・The most certain prevention for landslide ・Removing sliding soil mass results removing clay fraction ・Replacing with permeable material results reducing water pressure and scale of retaining wall ・Simple structure and easy construction ・Local material can be utilized	○

(Reffer Standard for Land Improvement Planning, Farmland Landslide Prevention Measures on 「Type」「Compatibility Condition」「Merit」「Demerit」

2-2-2-8-5 Basic Design of Countermeasures against Landslides

(1) Construction of a Retaining Wall

There are several types of retaining walls often built such as Type Inverted-T wall, Type L wall, leaning wall, gravity wall. It is necessary to build a high retaining wall because of the site conditions. Therefore, a Type L wall (6 meters high) is most suitable for the sheathing works because (a) the Type L wall is built of reinforced concrete which makes the wall height no limitation and (b) it can separate the access road and roadside ditch. In addition, the landslide surface is formed to be the incline of V : H = 1 : 2.0.

(2) Safety and Stability Analysis of the Slope after Implementation of the Countermeasures

① Safety factor of the slope after the countermeasures are implemented

Here, we examine the safety of the slope assuming that the countermeasures aforementioned in the previous section are implemented. In the normal case, we have to plan the countermeasures so that the safety factor (SF) against sliding slide is 1.20 or more.

② Soil constants

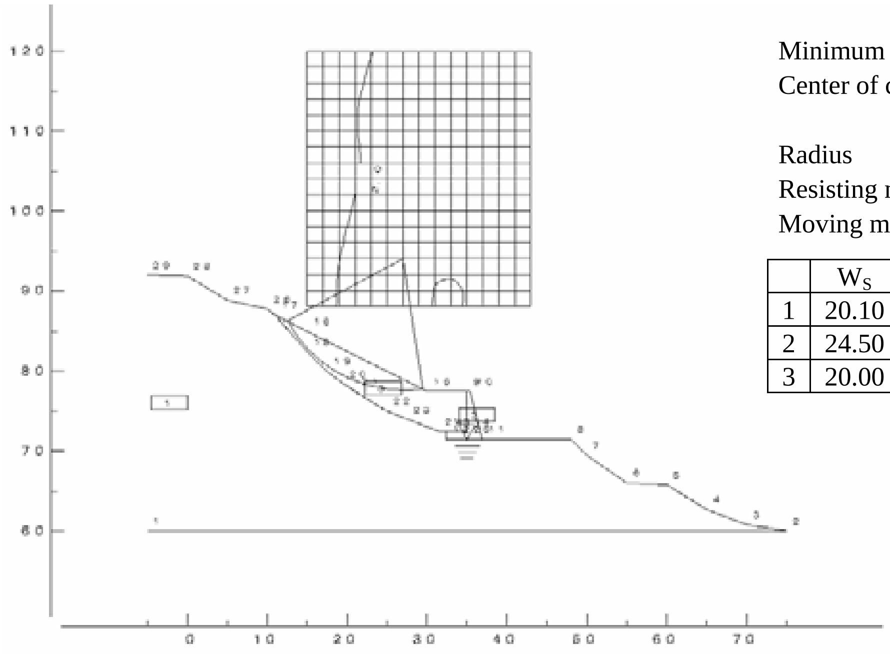
The following table shows the soil constants of river sand gravel used to replace the sliding soil mass, with those of the ground aforementioned,

Soil Parameter

Item	Soil internal friction angle		Cohesion (KN/m^2)	Unit weight (KN/m^3)	
	φ	Evidence	c	saturated	wet
Natural ground	40.0 °	literature	0	20.1	18.5
Sand, gravel	30.0 °	literature	0	20.0	18.0

③ Analysis result

The result of the analyses is as follows. It shows that the slope is safe after implementation of the countermeasures, because SF = 1.274 > 1.20



Minimum safety	Fs $_{MIN}$	=	1.274
Center of circle	X	=	27.00 m
	Y	=	94.00 m
Radius	R	=	16.42 m
Resisting moment	MR	=	5,785 kN･m
Moving moment	MO	=	4,541 kN･m

	W_S	W_W	φ	C	C_C	E_H	E_V
1	20.10	18.50	50.00	0.0	0.0	0.0	0.0
2	24.50	24.50	45.00	100	0.0	0.0	0.0
3	20.00	18.00	30.00	0.0	0.0	0.0	0.0

W_S: Saturated unit weight of soil
W_W: Wet unit weight of soil
φ: Soil internal friction angle
C: Soil Cohesion
C_C: Coefficient for Cohesion
E_H: horizontal seismic coefficient
E_V vertical seismic coefficient
Unit weight of water: 9.80kN/m^3

Figure 2-2.18 Stability Analysis Result:
CASE 3 Slope Stability after implementation of the countermeasures for Landslide

④ Standard cross-section of the concrete retaining wall structure

The stability analysis results in the standard cross-section shown below.

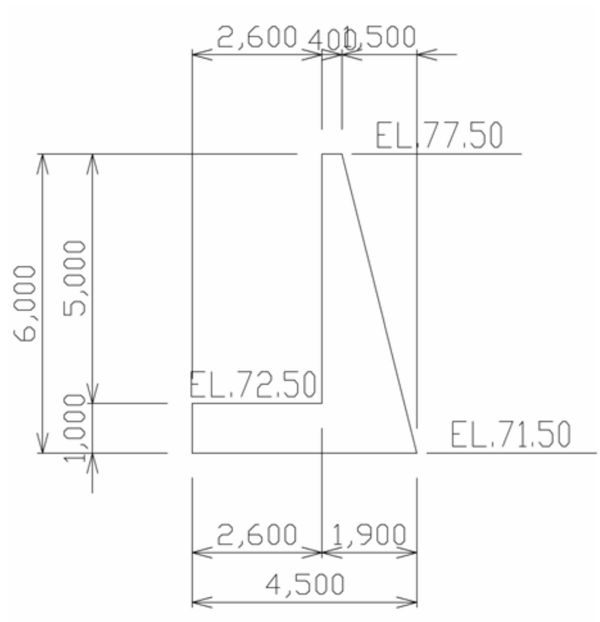


Figure 2-2.19 Typical Section of Retaining Wall

(3) Others

- In order to make the backside drainage effective, the retaining wall is backfilled with pervious materials. Moreover it has weep holes through the stem and drainage works, which is connected to the roadside ditch, on the footing.
- The retaining wall is divided at the longitudinal center with the expansion joint, where waterstops and dowel bars are installed.
- It is hard for the landslide surface to be stable because of its steepness after removing the sliding soil mass. Therefore, the sliding soil mass is replaced with proper materials so that the slope of the landslide surface is milder and stable.
- The proper materials abovementioned mean good soils in terms of strength and permeability. The river sand grave of Comoro River, which is easily available, will be one of proper ones in the vicinity of the site.
- In order to protect neighboring slope faces, the upper part of the landslide surface is protected with gabions after forming the slope to be stable (See Figure 2-2.20).

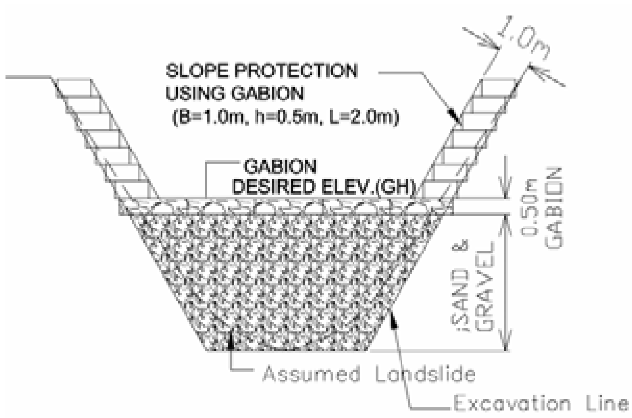


Figure 2-2.20 Typical Section of Slope Protection in Upside of Landslide Area