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

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR URGENT IMPROVEMENT
OF
WATER SUPPLY SYSTEM IN BEMOS-DILI
IN
THE DEMOCRATIC REPUBLIC OF TIMOR-LESTE

March 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

SANYU CONSULTANTS INC.

PREFACE

In response to a request from the Government of the Democratic Republic of Timor-Leste, the Government of Japan decided to conduct a basic design study on the Project for Urgent Improvement of Water Supply System in Bemos-Dili and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Timor-Leste a study team from June 6^{th} to July 4^{th}, 2008 and from October 15^{th} to October 27^{th}, 2008.

The team held discussions with the officials concerned of the Government of Timor-Leste, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Timor-Leste in order to discuss a draft basic design, and as this result, 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.

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 teams.

March 2009

Ariyuki Matsumoto
Vice-President
Japan International Cooperation Agency

March 2009

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Urgent Improvement of Water Supply System in Bemos-Dili in the Democratic Republic of Timor-Leste.

This study was conducted by Sanyu Consultants Inc., under a contract to JICA, during the period from May 2008 to March 2009. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Timor-Leste and formulated the most appropriate basic design for the project under Japan's Grant Aid Scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Tatsuhiko Mori

Project manager,
Basic design study team on
the Project for Urgent Improvement of
Water Supply System in Bemos-Dili in
the Democratic Republic of Timor-Leste.

Sanyu Consultants Inc.

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 population (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 government of Timor-Leste formulated the national development plan on May 2002, where two (2) development targets as below are fixed with highest priority-given target among others.

1) Poverty eradication
2) Promotion of fair and sustainable economic growth and enrichment in health, education and welfare for the people

As the strategy for attaining the development targets as mentioned, concerning the water supply sector, the government set the first priority in "Sustainable water supply safe and sufficient in qualitative and quantitative terms" where more than 80% of urban residents be secured with safe water supply for 24 hours. Concerning the water supply conditions in Dili city, the necessity of further efforts is identified in the Sector Investment Program (SIP) report as prepared in April 2006 and some additional project implementations are expected so as to improve the overall sustainability of Dili Water Supply System.

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.

The following table shows the contents of the request made by the government of Timor-Leste, project contents as defined from the JICA's preliminary study and those contents confirmed through the basic design study. Of the above, the requests concerning the rehabilitation of the Lower Service Reservoir and valve chamber were made by the government of Timor-Leste during the field survey by the basic design study team and duly confirmed in the additional field survey in October, 2008.

Contents of Request by the Government of Timor-Leste

First Request by the recipient country	After Preliminary Study	MD contents at the BD stage
(1). Replacement for the piping between the Bemos intake and No.3 river crossing, with an approximate length of 4.4 kilometers, specifically:	(1) Rehabilitation and improvement of Bemos Raw Water Main	(1) Rehabilitation and improvement of Bemos Raw Water Main
a. The pipe installation on the hillside along Bemos river,	• Replacement of parts of the 250mm and 300mm diameter steel pipe to avoid and minimize possible damage thereto by the torrential runoff after heavy rain.	• Replacement of parts of the 250mm and 300mm diameter steel pipe to avoid and minimize possible damage thereto by the torrential runoff after heavy rain.
b. 3 places of river crossing including the Aqueduct at No.1 river crossing and embedded pipe inside the river bed at No.2 river crossing and No.3 river crossing,	• Repair of pipe supports and bank protection damaged by the flood,	• Repair of pipe supports and bank protection damaged by the flood,
	• Provision of additional concrete supports, protection walls, groyne, concrete blocks, foot protection and other measures to protect the raw water main, as required,	• Provision of additional concrete supports, protection walls, groyne, concrete blocks, foot protection and other measures to protect the raw water main, as required,
c. Improvement of the water intake facilities, and	• Reinforcement of the pipe protection particularly at the river crossings, and construction of pipe bridge(s) when considered cost –effective and appropriate,	• Reinforcement of the pipe protection particularly at the river crossings, and construction of pipe bridge(s) when considered cost–effective and appropriate,
d. Other required reinforcement works.	• Provision of an additional wash-out(s) with necessary appurtenances as required,	• Installation of an additional air valves and wash-outs, including isolating valves with necessary appurtenances as required,
(2) Reinforcement for the piping route between Bemos water treatment plant and No.3 river crossing, with a length of approximately 3.5 km.	• Installation of a flow controller on the raw water main to regulate water flow, when required, and	• Installation of a flow controller on the raw water main to regulate water flow, when required, and
a. The gabion installations at the required places for reinforcement.	• Other necessary work, as required.	• Other necessary work, as required.
b. Other required reinforcement work.	(2) Rehabilitation and improvement of the intake	(2) Rehabilitation and improvement of the intake
	• Rehabilitation of weir to minimize leaks and infiltration through the concrete walls and the base, and	• Rehabilitation of weir to recover erosion and increase stability, and
	• Rehabilitation of intake chamber by providing screens and any other devices to minimize entrance of foreign matters like sand, silt, and leaves into the chamber.	• Rehabilitation of intake chamber by providing screens and any other devices to minimize entrance of foreign matters like gravels, sand, silt, and leaves into the chamber.
(3) All the section		
(No particulars)	• Installation of isolating valve box	• Additional isolating valve and installation of box
	• Shifting and reinforcement of air valve and chamber	• Shifting, adding and reinforcing of air valve and chamber
(4) Bemos Water Treatment Plant		
Rehabilitation of the Lower Service Reservoir and valve chamber		• Rehabilitation of the Lower Service Reservoir and valve chamber

(3) Outline of Study Result and Project Components

In response to the request made by the government of Timor-Leste, the government of Japan decided to conduct a basic design study on the Project for Urgent Improvement of Water Supply System in Bemos-Dili and JICA dispatched a basic design study team to the project site during the period from June 6 to July 4, 2008. The basic design 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 concerning the damaged conditions of Bemos raw water main as well as Bemos intake weir and O & M practices and finally confirmed the necessity and justification to implement the subject rehabilitation/improvement project at the earliest. Further, it was during the period from October 15 to 27, 2008 that another study team was dispatched to the site additionally to survey/study on rehabilitation of the Lower Service Reservoir and valve chamber attached to Bemos water treatment plant. After the follow-up study in Japan, the study team had finalized the draft final report and JICA dispatched another team to explain about the content of the said report during the period from January 26 to February 1, 2009. After due discussion and confirmation with the government agencies concerned, the contents of the said report have been fully agreed upon by the both parties.

Concerning the selection and priority-rating for the pipeline sections to be rehabilitated under the project, attention/considerations were given on the following points.

- Those sections viable for sustainable use in future shall remain as they are as much as possible.
- Level of damages caused
- Importance of the section
- River flow condition in each section

As for the design of facilities, such structures which can satisfy the followings were adopted.

- To secure adequate durability/sustainability in each station from the disaster prevention viewpoint
- To cause easier O & M works for DNSAS staff

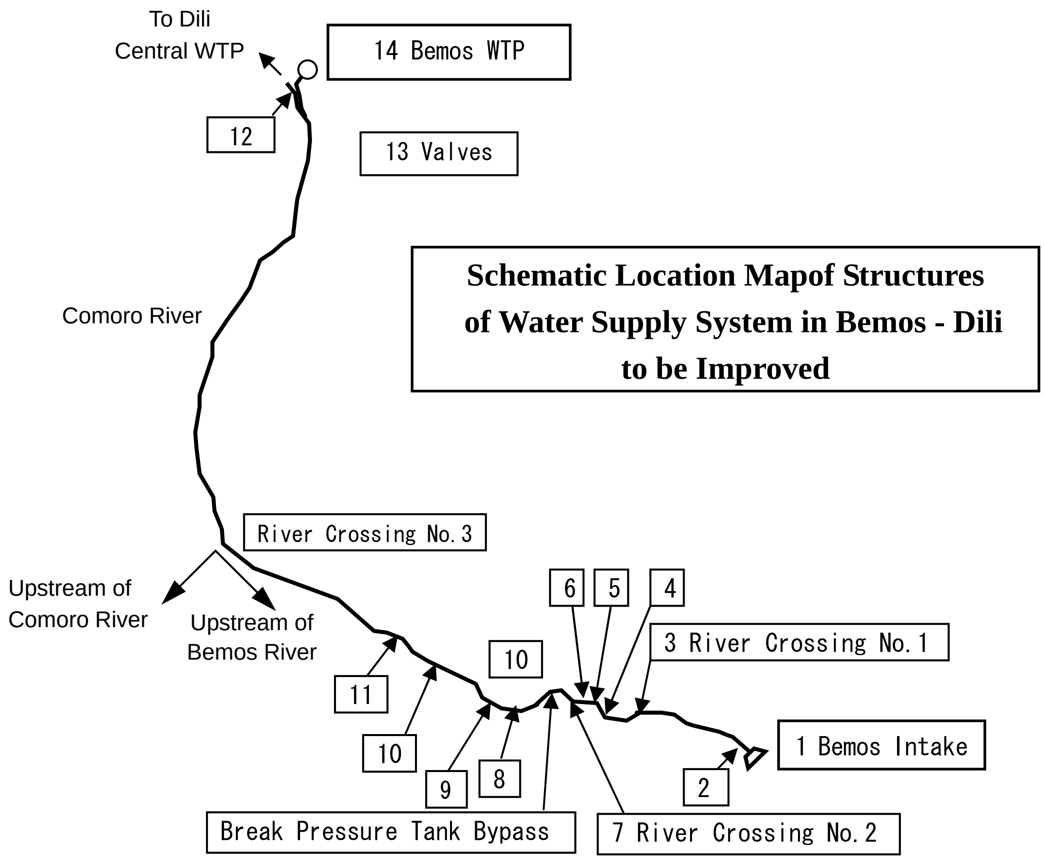
The Lower Service Reservoir and valve chamber of the Bemos water treatment plant were decided to be rehabilitated under the project based on the result of additional site survey and study. While for the construction planning, due attention was paid on the following points.

- Main construction sites are in narrow strip along the steep slope river
- Construction can be done only during the dry season from May to October
- No disturb/suspension of water supply even in the construction period

As the result of the subject basic design study, the project components have been confirmed as shown in the following table.

Contents of Project Works

Work items	Length	Rehabilitation / Improvement manner
1. Intake weir	-	• Construction of sand sluiceway • Improvement of apron and river bed protection • Repair of crest and abutment
2. Inlet and Grit chamber	17 m.	• Improvement of inlet • A part of pipeline be changed to connecting canal • Construction of grit chamber • Construction of Sand Sluice canal
3. 0+495 ~ 0+545 River crossing No.1	50 m.	• Concrete reinforcement on existing pipeline protection • Construction of groundsill and river bed protection at lower stream reach • Scouring Protection Revetment on both banks • Construction of wash-out
4. 0+584 ~ 0+742 Right bank river terrace, crossing with tributary and existing wing of retaining wall	200 m.	• Change of pipeline route and tributary crossing by aqueduct • Construction of Flow Path at the tributary crossing • Construction of Wash-out
5. 0+787 ~ 0+876 Existing upstream concrete retaining wall	80 m.	• In between the retaining wall and upright rise around the pipe be re-filled with sand and gravel and covered by gabion • Retaining wall heightening (partially) • A part of pipeline be shifted
6. 0+876 ~ 0+947 Right bank river terrace	100 m.	• Revetment on river terrace
7. 1+142 ~ 1+220 River crossing No.2	80 m.	• Concrete reinforcement on concrete river bed protection • Construction of groundsill and river bed protection at lower stream reach • Scouring protection revetment on both banks • Construction of wash-out
8 1P34 / 1P36 (1+420 ~ 1+530) Existing downstream concrete retaining wall	59 m.	• In between the retaining wall and upright rise around the pipe be re-filled with sand and gravel • Heightening of retaining wall (partially) • Foot protection works for foundation of retaining wall
9 1P42 (1+938) Left bank terrace of Bemos river	50 m.	• Protection of existing pipeline by revetment and re-filling by sand and gravel
10 2+094 ~ 2+200 Left bank terrace of Bemos river (Pipeline hanging in the air)	100 m.	• Route change and embedding the pipe in river bed • Encasement by concrete • River bed protection
11. 2+365 ~ 2+570 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
12. 7+000 ~ 7+100 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
13. Isolating valve, wash-outs	-	• Allocate as required for easier O&M
14. Bemos Water Treatment Plant The Lower Service Reservoir & valve chamber	-	• Renovate the facilities to have the same capacity and function with the existing ones



(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) Examination of Project Justification

The subject project aims at securing safe and sustainable water supply for the 57,000 people in zone 3 and zone 4 (35% of 160,000 residents) within the Dili water supply system service network. Through the implementation of the project, the Bemos-Dili water supply system would be rehabilitated to be more firm and sustainable system and even facing re-occurrence of flooding with similar intensity, the water supply function will not be disturbed. Further to mention, as the system will be provided with easier sand-flushing operation, water supply suspension for about 7 days in a year as previously forced regularly will not happen any more. This will lead to lessening of sand-flushing O & M works and sustainable raw water supply throughout the year. Moreover it can be said that designed discharge could be supplied in more sustainable manner throughout the year, as the obstructing factors for pipe water flow could be removed through installation of air valve and wash-outs. In view of the above, the following project effects can be expected by having such rehabilitation/improvement on the water supply system with the raw water source from Bemos river.

1) Direct Effect

- Continuous water supply is assured by the rehabilitation / improvement without the breaking-down of pipeline even in the considerable flood.
- The daily raw water supply from the Bemos river source will be increased by 13% from 7.8 thousands cubic meter to 8.8 thousands as the obstructing factors for pipe water flow could be removed through installation of air valve and wash-outs.
- As the system will be provided with easier sand-flushing operation, water supply suspension will be reduced from 7 to 0 days in a year.

2) In-direct Effect

- Through rehabilitating the Bemos raw water main to be more stable and sustainable facility, raw water supply to Dili water supply system becomes secured. This will contribute to improvement of water supply and sanitation condition of Dili city as a whole.
- By having sustainable raw water supply, more systematic O & M of water supply facilities and distribution become possible. This will contribute positively to initiating and set-up of water tariff collection system by DNSAS.

In order to bring about the concrete benefits to the residents of Dili city in the form of increased water supply quantity and service hours which are to be derived from the increased raw water supply effected by the implementation of the subject project, the following-mentioned associated conditions are necessary to be promoted and fulfilled mainly by DNSAS.

- Consolidation of distribution pipe network including main and branches
- Fixing contract for water supply and payment, connecting pipe works and education program for residents
- Making customer registration book and employment of meter-checker

Further, to cope with the above requirement, it is considered quite important to have the project effects as derived from ADB supported project which is being implemented at present be materialized as soon as possible.

The implementation of the subject grant aid project will bring about the project effects as mentioned above and at the same time it will contribute to the betterment of BHN for a number of the city residents. Accordingly, it is confirmed that the implementation of the subject project under the grant aid scheme of the government of Japan is highly justifiable. It is hoped those facilities to be rehabilitated/improved under the project will be fully utilized in future in a sustainable manner by the self-help efforts by Timor-Leste.

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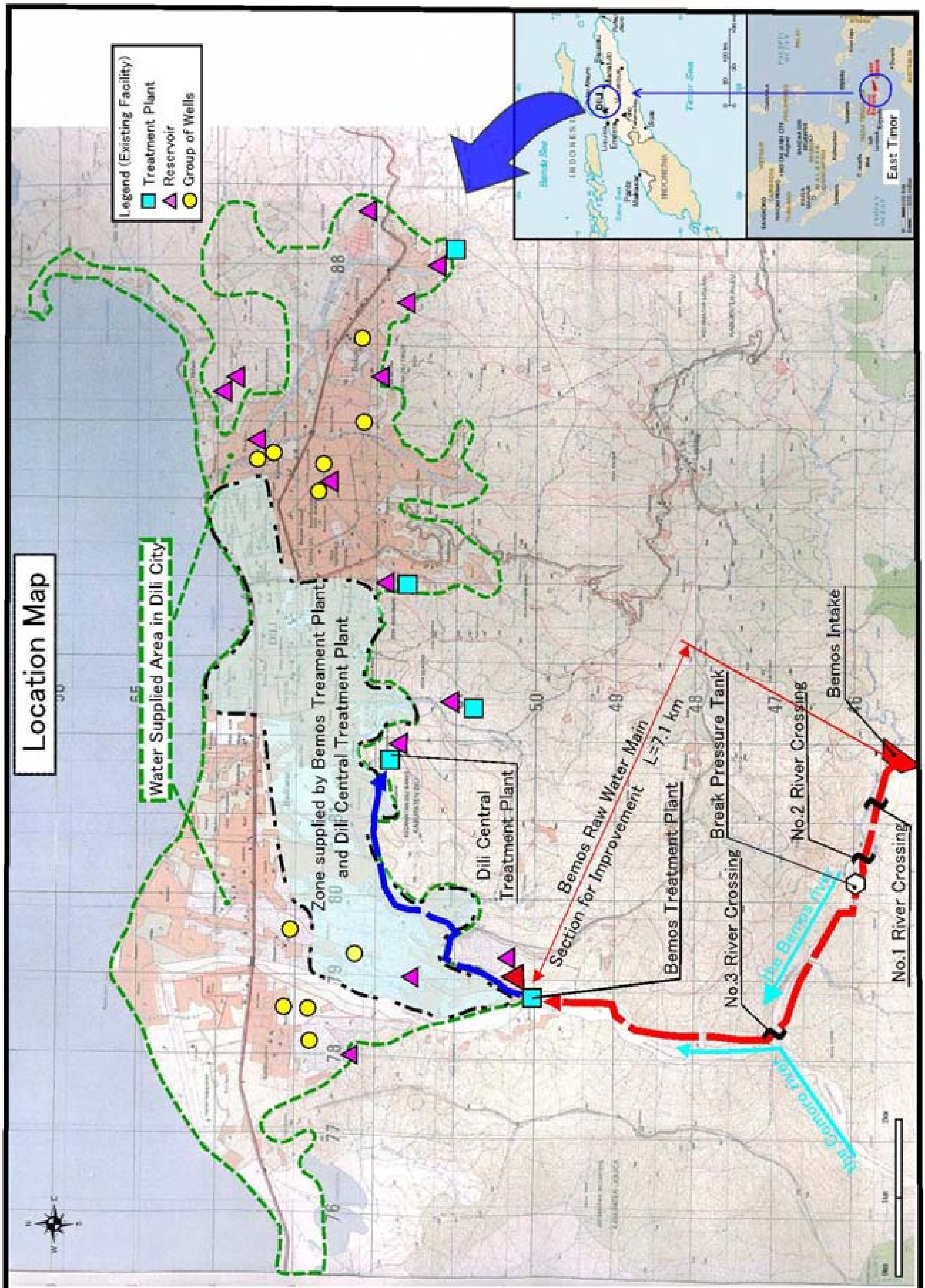
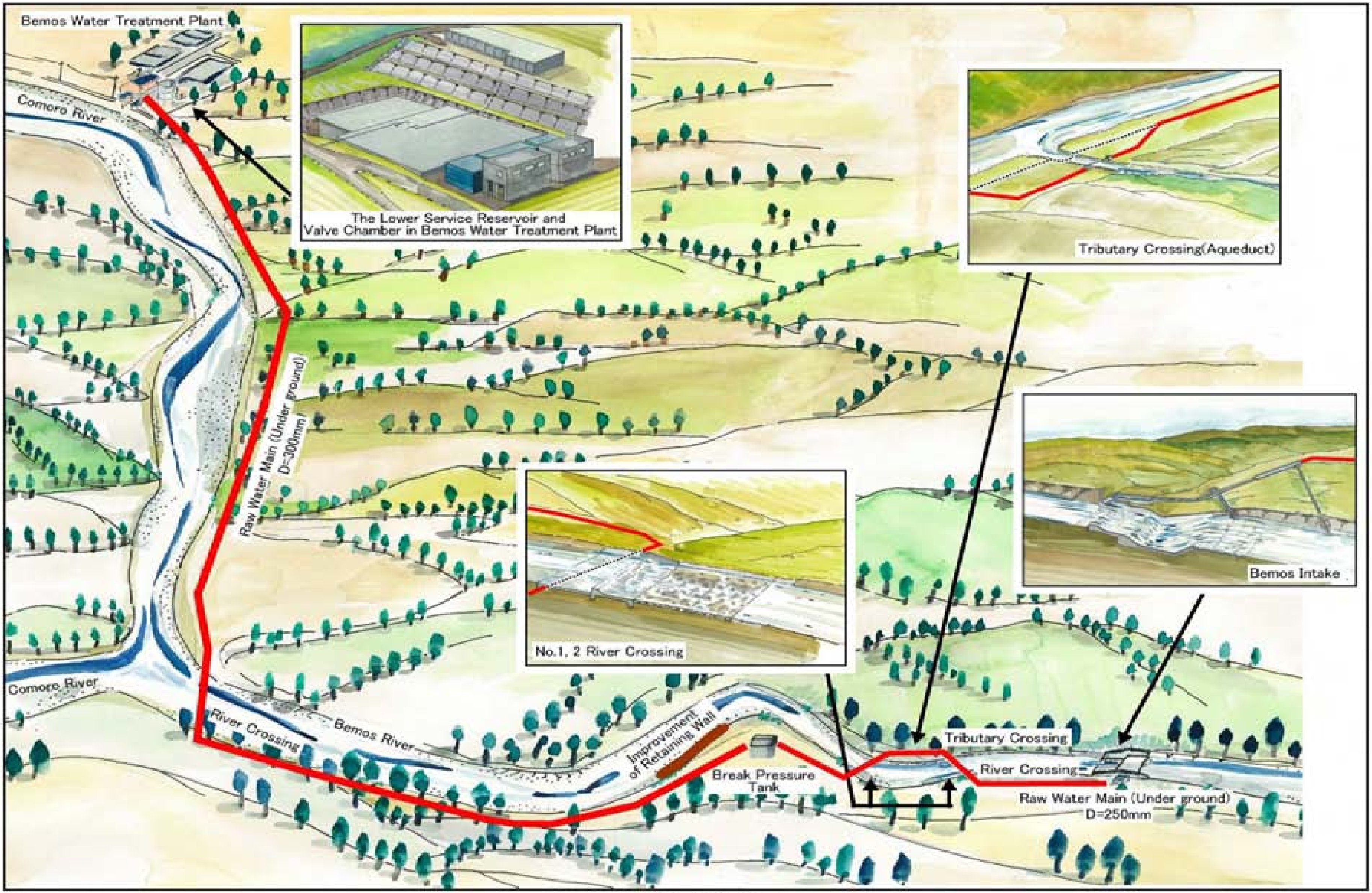
[Appendices]


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
No.3 River Crossing
Break Pressure Tank
No.2 River Crossing
Bemos Intake
No.1 River Crossing
the Bemos river
the Comoro river
Timor Sea
INDONESIA
East Timor



Perspective

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

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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		

<u>Currency</u>

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

<u>Exchange rate (July 2008)</u>

US$ = J.Yen 105.89

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 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 measures taken is not complete in various aspects. Currently, therefore, there occurred various problems as soil and bank erosions, exposed pipeline, collapse of slope, collision of boulder stone and etc. Accordingly, it is afraid that if in case there happened to be further flood damages on the raw water main facilities, the function will be totally lost.

While for the Lower Service Reservoir and valve chamber attached to the Bemos Water Treatment plant which had been constructed during 1980's, there found severe deterioration of concrete structures with considerable water leakage and judged to be renovated as soon as possible.

Damages and malfunctioning on raw water main and associated facilities by flooding in future may cause not only long suspension of water supply alone but also difficulty to access to safe water for the people and aggravation of the hygienic condition. In view of the foregoing, the Government of Timor-Leste made a request, on January 2006, for the subject 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.

Table 1-1.1 shows item by item the content of request by the Government of Timor-Leste, what was confirmed in the preliminary survey (Jan. – March, 2008) and the Governments request as confirmed in the present Basic Design study, in which the requests concerning the Lower Service Reservoir of Bemos Water Treatment Plant and valve chamber were made by the Government of Timor-Leste during the field survey by the Basic Design Study Team and confirmed in the additional field survey made thereon.

Table 1-1.1 Contents of Request by the Government of Timor-Leste

First Request by the recipient country	After Preliminary Study	MD contents at the BD stage
(1). Replacement for the piping between the Bemos intake and No.3 river crossing, with an approximate length of 4.4 kilometers, specifically:	(1) Rehabilitation and improvement of Bemos Raw Water Main	(1) Rehabilitation and improvement of Bemos Raw Water Main
a. The pipe installation on the hillside along Bemos river,	• Replacement of parts of the 250mm and 300mm diameter steel pipe to avoid and minimize possible damage thereto by the torrential runoff after heavy rain.	• Replacement of parts of the 250mm and 300mm diameter steel pipe to avoid and minimize possible damage thereto by the torrential runoff after heavy rain.
b. 3 places of river crossing including the Aqueduct at No.1 river crossing and embedded pipe inside the river bed at No.2 river crossing and No.3 river crossing,	• Repair of pipe supports and bank protection damaged by the flood,	• Repair of pipe supports and bank protection damaged by the flood,
	• Provision of additional concrete supports, protection walls, groyne, concrete blocks, foot protection and other measures to protect the raw water main, as required,	• Provision of additional concrete supports, protection walls, groyne, concrete blocks, foot protection and other measures to protect the raw water main, as required,
c. Improvement of the water intake facilities, and	• Reinforcement of the pipe protection particularly at the river crossings, and construction of pipe bridge(s) when considered cost –effective and appropriate,	• Reinforcement of the pipe protection particularly at the river crossings, and construction of pipe bridge(s) when considered cost–effective and appropriate,
d. Other required reinforcement works.	• Provision of an additional wash-out(s) with necessary appurtenances as required,	• Installation of an additional air valves and wash-outs, including isolating valves with necessary appurtenances as required,
(2) Reinforcement for the piping route between Bemos water treatment plant and No.3 river crossing, with a length of approximately 3.5 km.	• Installation of a flow controller on the raw water main to regulate water flow, when required, and	• Installation of a flow controller on the raw water main to regulate water flow, when required, and
a. The gabion installations at the required places for reinforcement.	• Other necessary work, as required.	• Other necessary work, as required.
b. Other required reinforcement work.	(2) Rehabilitation and improvement of the intake	(2) Rehabilitation and improvement of the intake
	• Rehabilitation of weir to minimize leaks and infiltration through the concrete walls and the base, and	• Rehabilitation of weir to recover erosion and increase stability, and
	• Rehabilitation of intake chamber by providing screens and any other devices to minimize entrance of foreign matters like sand, silt, and leaves into the chamber.	• Rehabilitation of intake chamber by providing screens and any other devices to minimize entrance of foreign matters like gravels, sand, silt, and leaves into the chamber.
(3) All the section		
(No particulars)	• Installation of isolating valve box	• Additional isolating valve and installation of box
	• Shifting and reinforcement of air valve and chamber	• Shifting, adding and reinforcing of air valve and chamber
(4) Bemos Water Treatment Plant		
Rehabilitation of the Lower Service Reservoir and valve chamber		• Rehabilitation of the Lower Service Reservoir and valve chamber

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

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 under this project are partial improvement on the existing pipeline of raw water main, 7.1km in length and reconstruction works of the existing service reservoir with an adjacent valve chamber in Bemos water treatment plant. During the JICA preliminary study conducted from January to February 2008, the study of the initial environmental examination (IEE) level was conducted for the project in accordance with the JICA guideline for environmental and social considerations. As the result of the study, it is confirmed that the project site is included neither in the nature park nor in the protective zone, and furthermore it is judged that the project implementation brings little or scarce negative effect on the environmental and social considerations.

In the basic design stage on July 2008, DNSAS made an application for the environmental categorization of the project and DENS notified DNSAS of the categorization of this project as Category C on July 11th, 2008. Accordingly, submission of Environmental Management Program (EMP) is not required for the project. In addition, little or no negative impact against either environment or society is expected through this project and particular mitigation measures are also not necessary. Furthermore, validity of environmental categorization of the project will be extended until the valid period covered by the Exchange of Notes (E/N) entered by and between two Governments for the subject grant aid project implementation (refer to Section 2-6).

The following tables show the environmental evaluation through the implementation of this 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 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 are required urgently from the viewpoint of disaster-prevention.

Based on the field surveys and analysis in Japan, high-priority facilities for rehabilitation are 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.

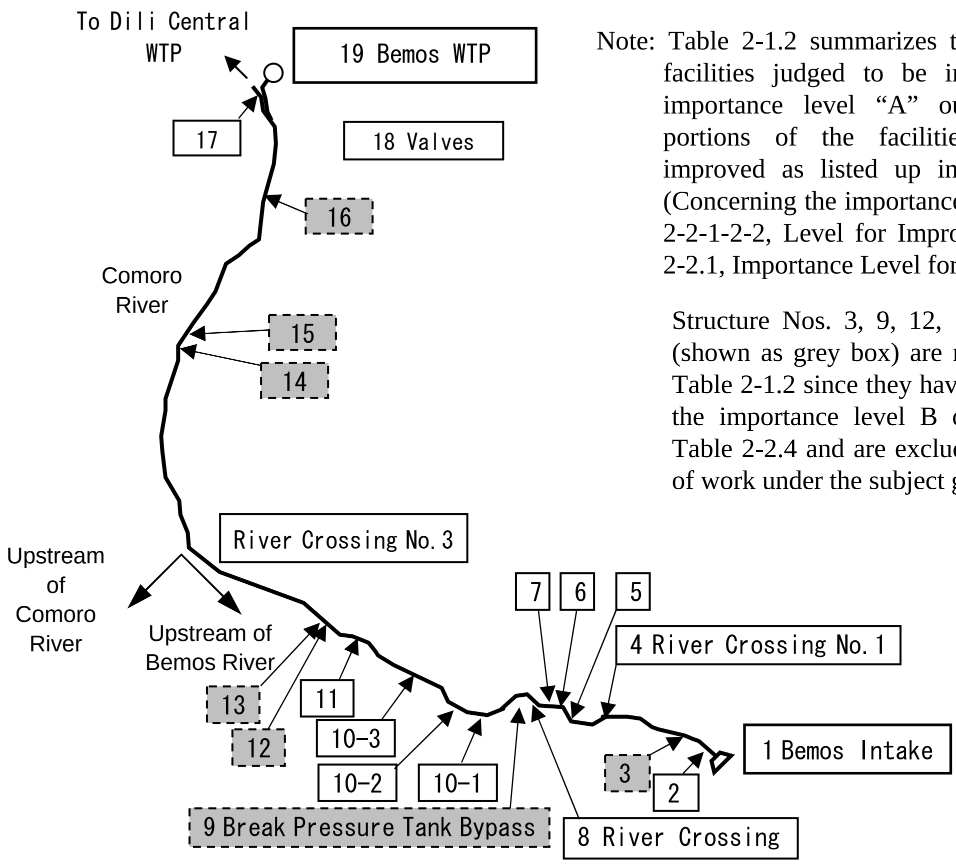
Furthermore, the Lower Service Reservoir and valve chamber in Bemos Water Treatment plant are to be rehabilitated based on the result of the additional field survey. Meanwhile, the construction schedule is planned in consideration of the matters to be concerned that the construction site is located in 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 are judged to be appropriate for rehabilitation / improvement for sustainably maintaining and securing raw water main function are shown in the following Table 2-1.2.

Table 2-1.2 Contents of Project Works

Work items	Length	Rehabilitation / Improvement manner
1. Intake weir	-	• Construction of sand sluiceway • Improvement of apron and river bed protection • Repair of crest and abutment
2. Inlet and Grit chamber	17 m.	• Improvement of inlet • A part of pipeline be changed to connecting canal • Construction of grit chamber • Construction of Sand Sluice canal
4. 0+495 ~ 0+545 River crossing No.1	50 m.	• Concrete reinforcement on existing pipeline protection • Construction of groundsill and river bed protection at lower stream reach • Scouring Protection Revetment on both banks • Construction of wash-out
5. 0+584 ~ 0+742 Right bank river terrace, crossing with tributary and existing wing of retaining wall	200 m.	• Change of pipeline route and tributary crossing by aqueduct • Construction of Flow Path at the tributary crossing • Construction of Wash-out
6. 0+787 ~ 0+876 Existing upstream concrete retaining wall	80 m.	• In between the retaining wall and upright rise around the pipe be re-filled with sand and gravel and covered by gabion • Retaining wall heightening (partially) • A part of pipeline be shifted
7. 0+876 ~ 0+947 Right bank river terrace	100 m.	• Revetment on river terrace

Work items	Length	Rehabilitation / Improvement manner
8. 1+142 ~ 1+220 River crossing No.2	80 m.	• Concrete reinforcement on concrete river bed protection • Construction of groundsill and river bed protection at lower stream reach • Scouring protection revetment on both banks • Construction of wash-out
10-1 1P34 / 1P36 (1+420 ~ 1+530) Existing downstream concrete retaining wall	59 m.	• In between the retaining wall and upright rise around the pipe be re-filled with sand and gravel • Heightening of retaining wall (partially) • Foot protection works for foundation of retaining wall
10-2 1P42 (1+938) Left bank terrace of Bemos river	50 m.	• Protection of existing pipeline by revetment and re-filling by sand and gravel
10-3 2+094 ~ 2+200 Left bank terrace of Bemos river (Pipeline hanging in the air)	100 m.	• Route change and embedding the pipe in river bed • Encasement by concrete • River bed protection
11. 2+365 ~ 2+570 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
17. 7+000 ~ 7+100 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
18. Isolating valve, wash-outs	-	• Allocate as required for easier O&M
19. Bemos Water Treatment Plant The Lower Service Reservoir & valve chamber	-	• Renovate the facilities to have the equal capacity and function with the existing ones



Note: Table 2-1.2 summarizes the portions of the facilities judged to be improved with the importance level "A" out of the overall portions of the facilities judged to be improved as listed up in the Table 2-2.4. (Concerning the importance level, please refer 2-2-1-2-2, Level for Improvement and Table 2-2.1, Importance Level for Basic Policy.)

Structure Nos. 3, 9, 12, 13, 14, 15 and 16 (shown as grey box) are not included in the Table 2-1.2 since they have been judged with the importance level B or C as shown in Table 2-2.4 and are excluded from the scope of work under the subject grant aid project.

Fig. 2-1.1 Schematic Location Map of Structures of Water Supply System in Bemos - Dili to be Improved

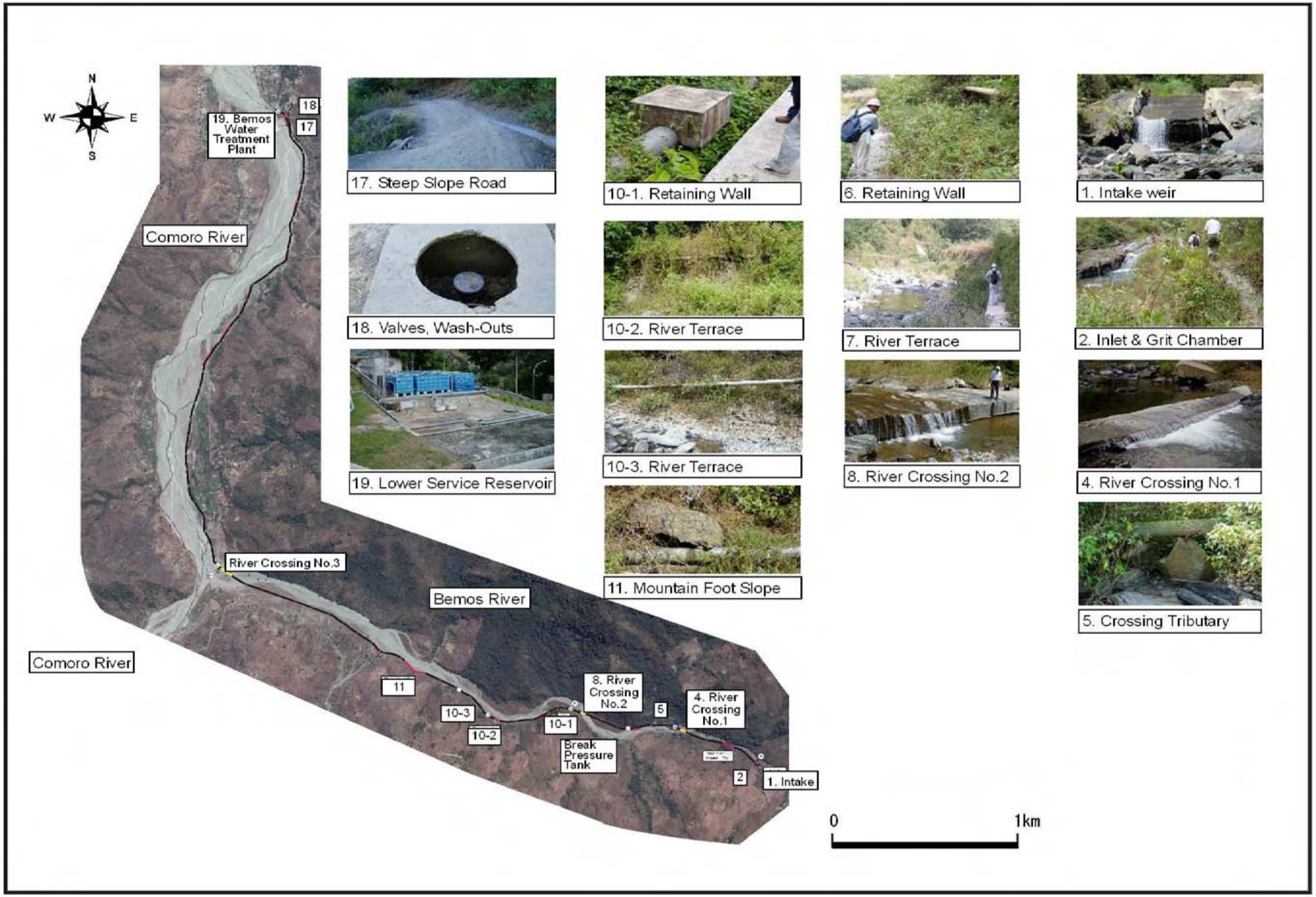


Fig. 2-1.2 Existing Conditions of Structures to be improved

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Scope of Request

The scope 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 which is requested additionally during the basic study survey. 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. However, smooth fundamental improvement of the facilities is needed because it will not function in case of occurrence of floods in future. Moreover, the improvement of the Lower Service Reservoir and its valve chamber, which were constructed in 1980’s and are still being operated, is necessary because of the aging and deterioration to avoid the situation that the said facilities be collapsed and city water supply be suspended.

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;

- Location of the existing intake weir is the same because of the difficulty to find anther hopeful water sources,
- The existing conveyance system of the Bemos Raw Water Main is recommendable because the free flow system of the existing one is advantageous on the economical point of view, and
- 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.

2-2-1-2-2 Level for Improvement

The level for improving facilities is prioritized and configured by the policy as shown in Table 2-2.1 on the degree of influence to the functional capability of the water conveyance facilities and depending on necessity and urgency of the improvement.

Level for improving facilities is categorized by 3 levels that are Level –A, Level-B and Level-C as shown in Table 2-2.1.

- Level-A is the portion to be improved under the Japan’s Grant Aid Project. These parts are judged to be urgently improved in order to keep its function of the conveyance system of the raw water main facilities.

- Level-B and Level-C are portions that do not need the advanced technique during the construction and are not higher urgency/priority than Level-A though it is necessary to improve as early as possible. Also, they are judged to be rehabilitated and maintained by the operation ad maintenance activities by DNSAS.

Although pipes are exposed by scouring of soil caused by floods in the portions of Level-B and Level-C, it is less likely to damage crucially as caused by flowing or falling stones newly. DNSAS can maintain it during the maintenance periods to cover pipes by soils in order to protect it from further damage.

Table 2-2.1 Importance Level for Basic Policy

Importance level	Basic policy
A	・The portions where drift stones and boulders in the river main stream has been exposed to rapid flow at flood and/or high possibility to be exposed. ・The portions where the raw water main has been exposed and damaged by the rockfalls, sliding and drift stones from the upper mountainside slope and/or high possibility to receive the damage. ・In addition to the above-mentioned, facilities indispensable to maintain properly the system of raw water main and so forth having urgent needs because of high possibility that the new water main system doesn't function when left as it is.
B	・The portions where the raw water main has been exposed by the scouring of floods but it has not been exposed directly to the rapid flow in the river main stream and/or it has been exposed to the rapid flow but without possibility of striking by the drift stones and boulders which may damage the pipes. ・The portions where the raw water main has been exposed and has possibility to receive the damage by the rockfalls, sliding and drifting stones from the upper mountainside slope or the tributary but it has low possibility of receiving fatal damage to the function of system such as the pipe breakage etc. And so forth which is preferable to repair as early as possible because there is a possibility to require more time and cost in restoring damaged functions when leaving it, though priority is not higher than rank A in terms of the emergency.
C	・The raw water main has not been exposed to the rapid flow in the river main stream directly excluding the portions of above-mentioned A and B. ・It can be continued for use even if it doesn't repair at once though there is a potential hazard.

For the portions which are found necessary to be improved but not included in the subject Project, semi-permanent improvement methods are presented in Appendix 5-7 as a reference only.

2-2-1-2-3 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

2-2-1-2-4 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. The result is shown in 2-2-2-4. 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 as shown in the section 2-2-2-4, Table 2-2.11.

- The revetment works of the flood channel is designed to follow the policies classified in the Table 2-2.2 according to the velocity at the design flood.
- When the exposed pipeline is protected from the river flow by revetment work, pipeline is buried with sand and gravel available at the site, and surface protection method of the revetment is selected as indicated in the Table 2-2.2 based on the velocity of the stream of the flood channel in the upper part of the pipeline.

Table 2-2.2 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 by the section 2-2-2-6 and Table 2-2.18 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.

2-2-1-2-5 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 based on the policy as described in the section 2-2-1-2-7.
- If necessary, the protection works to the scouring and rock fall as described in the section 2-2-1-2-4 is planned to the changed route.

2-2-1-2-6 Policy of Rehabilitation of River Crossing

The Bemos raw water main crosses the Bemos river in three places. As showing the situation of the existing river crossings in Table 2-2.4, the first and the second river crossing works are necessary to be rehabilitated because of receiving struck, while the third river crossing work functions healthily.

As the first river crossing works where the pipeline was broken due to the flood in 2004 but later replaced at the downstream and the second river crossing works can be used. Then, the policy to both river crossing work is to minimize the rehabilitation, new construction and change route through the improvement of the existing facility.

(1) River Crossing No.1

The improvement policy of the river crossing No.1 is as follows;

① The existing one, which was repaired in 2004, is found possible to be used in the future because the main body of the pipeline and the concrete protection of the river crossing work are soundly functioning.

② Main body of existing pipe and concrete protection works has no earth covering. According to the river preventing sand erosion standard, it is mentioned that the earth covering of the river crossing works shall have 2.0m in depth. However, it is planned that concrete slab is newly installed for the protection works because it is difficult to secure 2.0m of earth covering.

③ The present riverbed drop is 0.50m, and the one at the river crossing point becomes 1.00m when the concrete slab is newly installed. Therefore, groundsill and riverbed protection are newly constructed in order to stabilize the riverbed.

④ The existing right and left revetments have to be repaired because these were washed away during the flood in 2004 and 2005. The revetment of low water channel is designed in accordance with the height of the low water channel and velocity at the control discharge as shown in Table 2-2.11 in the section 2-2-2-4 considering the economic point of view.

⑤ The new wash-out is to be installed at the upstream side of pipeline, inside (landside) of dike and the nearest to the river to discharge in the lower part of the pipeline route. The diameter of the sand wash-out pipe is planned with ϕ200mm.

(2) River Crossing No.2

The improvement policy of the river crossing No.2 is as follows;

① The existing one, which was newly constructed in 2003, is found possible to be used in the future because the main body of the pipeline and the concrete protection of the river crossing work are soundly functioning.

② Main body of existing pipe and concrete protection works has no earth covering. According to the river preventing sand erosion standard, it is mentioned that the earth covering of the river crossing works shall have 2.0m in depth. However, it is planned that concrete slab is newly installed for the protection works because it is difficult to secure 2.0m of earth covering.

③ The present riverbed drop is 0.60m, and the one at the river crossing point becomes 1.10m when the concrete slab is newly installed. Therefore, groundsill and riverbed protection are newly constructed in order to stabilize the riverbed.

④ The existing right and left revetment has to be repaired because these were washed away due to the flood in 2004 and 2005. The revetment of low water channel is planned considering the economic point of view according to the height of the low water channel and velocity at the control discharge as shown in Table 2-2.11 in the section 2-2-2-4.

⑤ The existing wash-out (WR80-02) installed at downstream side and inside of dike is required to relocate the drain outlet of wash-out pipe. The wash-out pipe is realigned with ϕ80mm GSP in diameter equivalent to the existing one.

2-2-1-2-7 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 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 2-2.3 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.

- It is necessary to consider designing properly so that the contamination of raw water should not happen because it is an important water source of Dili City.

- 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.

2-2-1-5 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 (Facility 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%]

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

$= 102$ liter/sec

Where; 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 Selection of Facilities to be Rehabilitated/Improved

Site investigations were conducted on the Bemos intake weir, the Bemos Raw Water Main and the Lower Service Reservoir as additional facility according to the basic policy described in the section 2-2-1-2. The result of the investigations is shown in Table 2-2.4 and portions which are judged to be improved in order to keep the functions of water conveyance from Bemos river in safety and stably.

Table 2-2.4 Portions of the Facilities Judged to be Improved

Portions to be improved and Structure No.		Length	Problems found in investigation	importance level
1	Intake weir	—	・Wear and tear of the surface of crest, chute portion, and guide wall. ・The foundation of the downstream of the apron (chute portion) and the gabion of the energy dissipater basin was completely washed out and the downstream looks like a basin of water fall. The function of weir shall be lost in case of further scouring.	A
2	Inlet and Grit chamber	17 m	・As a large amount of soil and sand, gravel, and fallen leaves etc. has entered into the existing raw water main, O&M for the facility becomes difficult as it causes increasing the suspension days of the water supply. ・The existing facility makes it difficult to operate for sand flush and dust removal etc.	A
3	0+220 to 0+260 Rock fall protection in the left bank	41 m	・There is a possibility that the large rocks supported by underneath rocks may fall down on the pipeline in the exposed section when happening large scale earthquake (No trace of damages be found on the pipeline, though.)	C
4	0+495 to 0+545 River crossing No.1	50 m	・As the pipeline was broken due to the flood in 2004, it had been replaced to the downstream side. There is a scouring of riverbed at the downstream side of the protection concrete replaced. ・River terrace in the right bank, where had existed at the time of the construction, was eroded, and stand-up portion of the pipeline has been exposed. As this part is a water passage with floods, it is expected that a further scouring and the boulder stone, etc. cause damage to the pipeline.	A

Portions to be improved and Structure No.		Length	Problems found in investigation	importance level
5	0+584 to 0+742 River terrace in the right bank, tributary crossing and the existing wing of retaining wall	200 m	・The buried pipeline of 23m is exposed and hanged because the river terrace in the right bank have been scoured by floods. ・The section of 20m of the existing pipeline in the tributary crossing is concrete lined, and the downstream side is scoured by about 0.4m. ・The breaking away of the pipes is expected in case the scouring by the drift stones and boulder etc. further proceeds during floods.	A
6	0+787 to 0+876 Existing upstream concrete retaining wall	80 m	・As this section, where buried in the riverbank, was exposed by the flood in March, 2005, DNSAS reinforced the section of river side portion with concrete retaining wall. ・As there are a lot of falling rocks on the upstream side, the pipeline was damaged in the surrounding of IP23. The retaining wall in the downstream part is judged that the flow is overflowed at the flood.	A
7	0+876 to 0+947 River terrace on the right bank	100 m	・Water route shifts from nearby the end of upstream concrete retaining wall to the left bank, and there is no remarkable scour mark in the slope (vertical almost) in the river terrace on the right bank side at this moment, however, there is a part of collapse. when the passage changes, it is possible that the pipeline will be exposed and hanged by the scouring.	A
8	1+142 to 1+220 River crossing No.2	80 m	・The riverbed protections by gabions in the left and right banks were washed out except that of the concrete block in the center part in the river, then the downstream of riverbed protection was largely scoured. ・Especially, the scouring on the left bank side is intense, and the gabion was washed away, then the concrete riverbed protection on the downstream side was scoured by 1m or more up to reach the foundation. The downstream side becomes a steep slope water course. ・The foot protection of the revetment on the left bank side was washed away, and the gabion was deformed. ・The revetment on the right bank side has almost no damage because it is not a water passage part	A
9	1+358 Bypass pipes of Pressure Break Tank	—	・The rust of the by-pass pipes progresses. ・No valve chamber for sluice valve of by pass pipes. ・It leaks from the drain valve of the raw water main on the downstream side.	C
10-1	IP34 / IP36 (1+420 to 1+530) Existing downstream concrete retaining wall	59 m	・Though the gabion revetment had been set up in this section, DNSAS had constructed concrete support stands because the underground pipeline had been washed away and exposed due to the flood in 2004. However, a part of the stands have been washed away due to the flood in 2005. ・Moreover, the river side has been reinforced by the construction of the concrete retaining wall, however, the lower side of the foundation of the wall has the danger of falling by scouring at this moment. ・ There is a fear of damage because of the falling rock because an upper mountainside of the pipeline is a slope of highly weathered rocks, and the falling rock lies scattered around the pipeline exposed.	A
10-2	Nearby IP42 (1+938) Left bank terrace of Bemos river	50 m	・In the nearby of IP42, a low river terrace receives scouring and the pipeline exposes and stuck in the natural ground skirts. There is a possibility that the flow extends to the nearby the piping route at the flood. ・The rockfall is seen in the surrounding, and there is fear of damage to the pipeline exposed.	A

Portions to be improved and Structure No.		Length	Problems found in investigation	importance level
10-3	2+094 to 2+200 Left bank terrace of Bemos river (pipeline hanging in the air)	100 m	・As the river terrace suffered from the scouring by floods and the foundation of the terrace washed out, the pipeline hangs in the air in about 100m. ・It is possible that the pipeline in the air hanging section increases further and is damaged, because the river terrace in the upper and lower section might be washed out easily by scouring during floods.	A
11	2+365 to 2+570 Mountain foot slope of left bank of Bemos river	179 m	・The pipeline is exposed in the nearby of IP50. A slope on the surface ground in this section forms highly weathered rocks so that the unsteady stones lies scattered. ・The rockfalls which hit the pipeline lie scattered around the pipeline.	A
12	IP55 (2+700) Tributary crossing on the left bank	20 m	・The pipeline is exposed in the tributary crossing on the left bank of Bemos river. The pipeline in the upstream side of the tributary (left side) is buried by soil and sand and is scoured in the downstream side (right side).	B
13	IP56(2+730) to tributary crossing on the left bank	20 m	・Crossing on the downstream side where the tributary diverges. The concrete lining protection (20m in length) is being exposed, and the upstream side of the protection is buried by the sedimentation, and the downstream side is scoured.	B
14	5+172 to 5+234 Right bank on the Comoro river (irrigation canal intersection)	57 m	・The access road along which the pipeline was laid to the village in the Comoro river right bank was constructed at first, however, the pipeline of the downstream from IP84 is exposed by the scouring of Comoro river, and has crossing with a new irrigation canal (the soil canal: about 20cm in depth).	C
15	5+323 to 5+475 Exposing pipeline at road crossing	150 m	・The pipeline extension in the section from 5+323 to 5+475 has been exposed in total of 31m which consists of 15m at road crossing and 16m at the shoulder. There is possibility of damage to the pipeline not only by the flood but also by the vehicle etc. when the present condition remains unchanged.	B
16	5+766 to 6+036 Tributary crossing on right bank of Comoro river	60 m	・At first the pipeline was buried under the gabion revetment and the access road embankment, however they were washed away by floods, so that the raw water main at this section is exposed with about 50m in length. Moreover, the pipeline is covered with debris from the tributary in the middle of the section. ・There are rockfalls from the tributary nearby the pipeline buried but neither rockfalls nor drift stones of the large size which may cause breaking of the pipes are seen.	B
17	7+000 to 7+100 Steep slope road section of the right bank of Comoro river	100 m	・ The raw water main is buried in the side strip of the steep slope (20%) road in the section of 60m from nearby the end of the downstream of the Bemos WTP. Since the road has been undermined by heavy rain in rainy season and the traffic by the vehicle, the pipeline has been exposed. In case if the present condition continues, there is a possibility that not only the pipeline be damaged with the vehicle but also the foundation of the pipeline is destroyed and the pipes fracture with the slope collapse.	A
18	O&M facilities such as new isolating valves, air valves, & wash-outs	—	・As there are a lot of inflows of earth and sand to the current state pipeline, sand flushing work is executed by the cutting of the pipe. ・It is assumed that air accumulation in the part of convex shape of the pipeline causes a partial failure of the flow. ・ It is necessary to arrange operation and maintenance facilities so that an appropriate control of operation and maintenance may become possible.	A

Portions to be improved and Structure No.		Length	Problems found in investigation	importance level
19	Bemos Water Treatment Plant The Lower Service Reservoir ($500m^3$) & valve chamber	—	・There is a danger of collapse of the facilities caused by the neutralization of concrete, the deterioration of strength, and deterioration of the rust of the reinforced bar. ・There is a repair mark and cracks in the wall. The stripping of concrete and the exposure of rusted reinforced bar is seen under the ceiling. ・Water leakage is observed.	A

In accordance with the selection policy of the facility to be improved stipulated in the section 2-2-1-2-2, facilities classified as importance level “A” in the above table are selected to be improved under the Project.

2-2-2-3 Design Flood Discharge

2-2-2-3-1 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 2-2.5 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 2-2.6　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 a 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 2-2-7　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	

2-2-2-3-2　Design Flood Discharge at the Point of Bemos Intake Weir

(1)　Catchment Area

Table 2-2-8　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

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 2-2-8.

(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 2-2.9.

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 2-2.9 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

Detail calculations of the design flood discharge refer to Appendix 5-1.

(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 (Table 2-2.7) 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 $110m^3/sec$.

Detail calculations of the control discharge refer to Appendix 5-1.

2-2-2-3-3 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 $10.5m^3/sec/km^2$.

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 $5.95m^3/sec/km^2$.

Detail calculations of the design flood discharge refer to Appendix 5-1.

2-2-2-3-4 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 2-2-10,

- 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 : $q_{bf} = 0.7 \times 53.9 / 3.6 =$ $10.5m^3/sec/km^2$
- Specific control discharge in the tributary : $q_{mc} = 0.7 \times 30.6 / 3.6 =$ $5.95m^3/sec/km^2$

Table 2-2.10 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)
1	Intake weir	Sta.0+000	mainstream	30.3	200	110
2	Grit chamber	Sta.0+075	mainstream	30.6	200	110
3	Rock fall protection for Bemos river left bank	Sta.0+220 to 0+260	tributary	0.05	0.5	0.3
4	River crossing No.1	Sta.0+495 to 0+545	mainstream	32.1	210	120
5	Tributary crossing of Bemos river right bank	Sta.0+650 to 0+787	mainstream tributary	32.6 3.20	220 34.0	120 19.0
6	Existing upstream concrete retaining wall	Sta.0+787 to 0+876	mainstream	33.1	220	120
7	Right bank river terrace of Bemos river	Sta.0+876 to 0+947	mainstream	33.4	220	120
8	River crossing No.2	Sta.1+142 to 1+220	mainstream	34.4	230	120
9	Break pressure tank bypass	Sta.1+358	—	—	—	—
10（1）	New upstream river crossing	Sta.1+425 to 1+475	mainstream	35.4	230	130
10-1	Existing downstream concrete retaining wall	Sta.1+420 to 1+530	mainstream	35.4	230	130

No.	Name of facilities	station	Type of river	Catchment area (km^2)	Design discharge (m^3/sec)	Control discharge (m^3/sec)
10-2,3	Left bank river terrace of Bemos river	Sta.2+025 to 2+125	mainstream	37.8	250	140
10(2)	New downstream river crossing	Sta.2+185 to 2+235	mainstream	38.1	250	140
11	Mountain foot slope of Bemos river left bank	Sta.2+365 to 2+570	mainstream	38.8	260	140
12	Tributary crossing No.1 of Bemos river left bank	Sta.2+700	mainstream tributary	40.0 0.90	260 10.0	150 5.4
13	Tributary crossing No.2 of Bemos river left bank	Sta.2+730	mainstream tributary	40.5 0.90	270 10.0	150 5.4
14	Intersection of irrigation canal of Comoro river right bank	Sta.5+172 to 5+325	mainstream	204.0	1,350	740
15	Road crossing of Comoro river right bank	Sta.5+325 to 5+475	mainstream	204.2	1,350	740
16	Tributary crossing of Comoro river right bank	Sta.5+766 to 6+036	mainstream tributary	204.7 0.40	1,350 4.2	740 2.4
17	Steep slope road of Comoro river right bank	Sta.7+000 to 7+100	mainstream	206.2	1,360	750

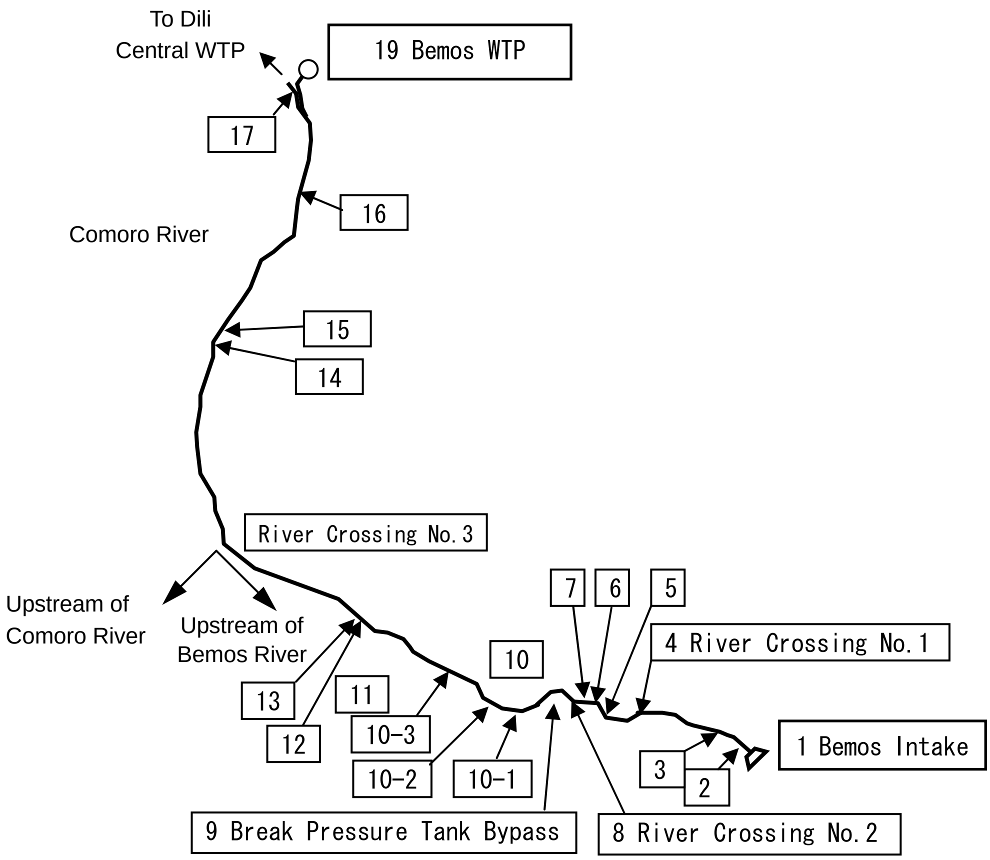


Fig. 2-2.1 Schematic Location Map of the Calculation Point of Design Flood Discharge

2-2-2-4 Hydraulic Design of River Cross Section

2-2-2-4-1 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.

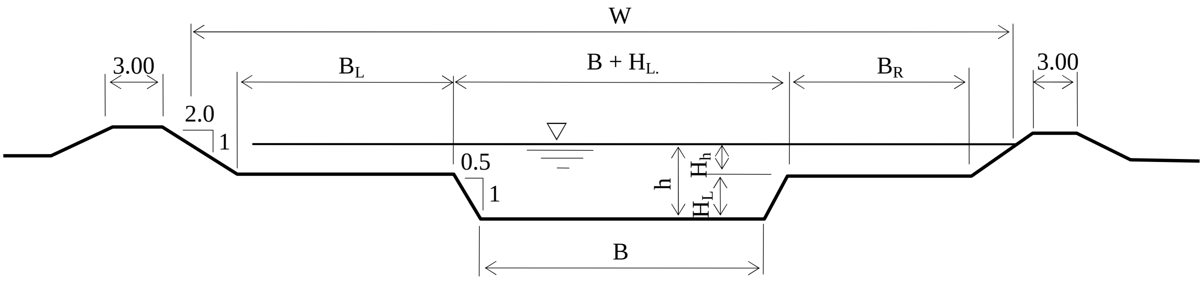


Fig. 2-2.2 Typical River Cross Section for Basic Design

2-2-2-4-2 Formula for Hydraulic Calculation of River Flow

(1) Formula of Velocity

Manning formula is adopted.

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

$hv = V^2 / 2 \cdot g$ -- (2)

Where、 hv : Velocity head (m)
g : Gravitational constant、g = 9.8m/sec^2

$Fr = V / \sqrt{g \cdot h}$ -- (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）、$U_* = \sqrt{g \cdot R \cdot I}$

2-2-2-4-3 Hydraulic Criteria in Each Structure (discharge, velocity, critical tractive grain size, etc.)

Table 2-2.11 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 2-2.11 Hydraulic Parameter of Design Discharge and Control Discharge at each Point

Point No.	Name of point	Station	Discharge (m^3/s)	Slope	Bottom width B and BL+Bk (m)	Water depth H_L H_h (m)	Velocity of design discharge (m/sec)	Velocity of control discharge (m/sec)	Type of flow	Critical tractive grain size (cm) At design discharge	Critical tractive grain size (cm) At control discharge
1.	Bemos intake weir（US, LWC）	Sta.0-025	200	1/33	15.0	1.50	6.29	(5.15)	SCF	63.75	(47.25)
	Bemos intake weir（US, FC）		(110)		6.0	0.50	2.46	—	SCF	15.60	—
	Bemos intake weir（DS, LWC）	Sta.0+050	200	1/25	12.0	1.50	7.20	(5.79)	SCF	83.79	(60.36)
	Bemos intake weir（DS, FC）		(110)		6.0	0.55	2.99	—	SCF	22.37	—
2.	Grit chamber（LWC）	Sta.0+075	200	1/25	12.0	1.50	7.20	(5.79)	SCF	83.79	(60.36)
	Grit chamber（FC）		(110)		6.0	0.55	2.99	—	SCF	22.37	—
3.	Rockfall protection of LB-BemR (tributary)	Sta.0+220	0.5 (0.3)	1/10	0.5	0.20 (0.15)	4.87	(4.35)	SCF	13.46	(11.36)
4.	River crossing No.1（LWC）	Sta.0+525	210	1/30	15.0	1.50	6.59	(5.40)	SCF	70.13	(51.98)
	River crossing No.1（FC）		(120)		10.0	0.50	2.68	—	SCF	18.15	—
5.	Trib Cross of RB-BemR（LWC）	Sta.0+675	220	1/20	11.0	1.60	8.05	(6.64)	SCF	104.62	(78.44)
	Trib Cross of RB-BemR（FC）		(120)		15.0	0.50	3.39	—	SCF	28.60	—
	Trib Cross of RB-BemR (tributary)		34 (19)	1/13	6.0	1.00 (0.70)	5.92 (4.86)	5.92 (4.86)	SCF	73.54	(54.75)
6.	Existing US Conc R.W. (LWC)	Sta.0+787	220	1/20	11.0	1.60	8.05	(6.64)	SCF	104.62	(78.44)
	Existing US Conc R.W. (FC)		(120)		15.0	0.50	3.39	—	SCF	28.60	—
7.	RB river terrace of Bemos river（LWC）	Sta.0+876	220	1/20	11.0	1.60	8.05	(6.64)		104.62	(78.44)
	Right bank river terrace of Bemos river(FC)		(120)		15.0	0.50	3.39	—		28.60	—
8.	River crossing No.2（US, LWC）	Sta.1+200	230 (120)	1/90	20.0	1.70	4.36	(3.44)	Sub-CF	28.63	(20.04)
	River crossing No.2（US, FC）				15.0	0.70	1.97	—	Sub-CF	8.72	—
	River crossing No.2（DS, LWC）			1/55	20.0	1.60	5.12	(4.24)	SCF	41.18	(31.09)
	River crossing No.2（DS, FC）				15.0	0.50	2.04	—	Sub-CF	10.40	—
10(1)	New US river crossing（LWC）	Sta.1+450	230	1/50	15.0	1.80	5.34	(4.64)	SCF	45.00	(36.45)
	New US river crossing（FC）		(130)		65.0	0.40	1.91	—	Sub-CF	9.61	—
10-1	Existing DS Conc R.W.（LWC）	Sta.1+420	230	1/50	15.0	1.80	5.51	(4.64)	SCF	47.14	(36.45)
	Existing DS Conc R.W.（FC）		(130)		45.0	0.50	2.20	—	CF	11.93	—
10-2,3	Left bank river terrace of Bemos river（LWC）	Sta.2+075	250	1/40	20.0	1.50	5.63	(4.79)	SCF	51.51	(40.36)
	Left bank river terrace of Bemos river（FC）		(140)		50.0	0.40	2.13	—	SCF	11.98	—

Point No.	Name of point	Station	Discharge (m^3/s)	Slope	Bottom width B and BL+Bk (m)	Water depth H_L H_h (m)	Velocity of design discharge (m/sec)	Velocity of control discharge (m/sec)	Type of flow	Critical tractive grain size (cm)	
										At design discharge	At control discharge
10(2)	New DS river crossing（LWC）	Sta.2+200	250	1/70	20.0	1.80	4.77	(4.03)	SCF	34.95	(27.10)
	New DS river crossing（FC）		(140)		35.0	0.50	1.86	—	Sub-CF	8.48	—
11.	Mountain foot slope of LB-BemR（LWC）	Sta.2+450	260	1/65	20.0	1.70	4.98	(4.04)	SCF	37.95	(27.75)
	Mountain foot slope of LB-BemR（FC）		(140)		35.0	0.60	2.17	—	Sub-CF	10.92	—
12.	Trib Cross No.1 of LB-BemR（LWC）	Sta.2+700	260	1/55	20.0	1.70	5.25	(4.40)	SCF	42.84	(32.80)
	Trib Cross No.1 of LB-BemR（FC）		(150)		35.0	0.50	2.10	—	Sub-CF	10.79	—
	Trib Cross No.1 of LB-BemR (tributary)		10.0 (5.4)	1/7	12.0	0.25 (0.17)	3.63	(2.84)	SCF	41.23	(28.45)
13.	Trib Cross No.2 of LB-BemR（LWC）	Sta.2+850	260	1/55	20.0	1.70	5.25	(4.40)	SCF	42.84	(32.80)
	Trib Cross No.2 of LB-BemR（FC）		(150)		35.0	0.50	2.10	—	Sub-CF	10.79	—
	Trib Cross No.2 of LB-BemR (tributary)		10.0 (5.4)	1/7	12.0	0.25 (0.17)	3.63	(2.84)	SCF	41.23 (28.45)	41.23 (28.45)
14.	Irrigation canal crossing at RB-ComR（LWC）	Sta.5+172	1,350	1/80	75.0	2.00	5.72	(4.92)	SCF	36.30	(28.96)
	Irrigation canal crossing at RB-ComR（FC）		(740)		40.0	0.50	2.01	—	Sub-CF	7.56	—
15.	Road crossing of RB-ComR（LWC）	Sta.5+323	1,350	1/80	75.0	2.00	5.72	(4.92)	SCF	36.30	(28.96)
	Road crossing of RB-ComR（FC）		(740)		310.0	0.50	2.01	—	Sub-CF	7.56	—
16.	Trib Cross of RB-ComR（LWC）	Sta.5+766	1,350	1/80	75.0	2.00	5.72	(4.92)	SCF	36.30	(28.96)
	Trib Cross of RB-ComR（FC）		(740)		310.0	0.50	2.01	—	Sub-CF	7.56	—
	Trib Cross of RB-ComR (tributary)		4.2 (2.4)	1/4.55	8.0	0.20 (0.12)	3.86	(2.84)	SCF	50.29	(31.84)

Notes

1: Figure described inside of parenthesis is at the control discharge
2: US; Upstream, DS; Downstream
3: LWC; Low Water Channel, FC; Flood Channel
4: SCF; Supercritical Flow, Sub-CF; Sub-critical Flow, CF; Critical Flow
5: RB; Right Bank, LB; Left Bank
6: BemR; Bemos River, ComR; Comoro River
7: RB-BemR; Right Bank of Bemos River, LB-BemR; Left Bank of Bemos River
8: RB-ComR; Right Bank of Comoro River, LB-ComR; Left Bank of Comoro River
9: Conc R.W.; Concrete Retaining Wall
10: Trib Cross; Tributary Crossing

2-2-2-5 Selection of Revetment

2-2-2-5-1 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.

2-2-2-5-2 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 be 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 2-2.11 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

Table 2-2.12 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)

The Table 2-2.12 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.

(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 2-2.13 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 2-2.13 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 2-2.14.

- 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.

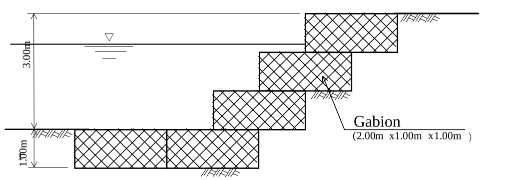
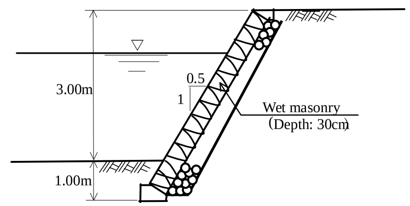
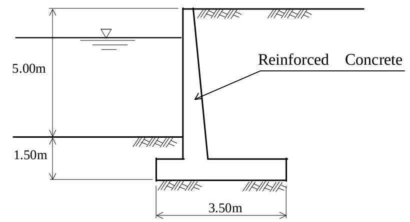
In the application of the revetment method, it is decided it considering the characteristic of each revetment method shown in Table 2-2.15 Revetment of River together with the applicable condition shown in Table 2-2.14.

Table 2-2.14 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 2-2.15 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)

2-2-2-6 Selection of Riverbed Protection

2-2-2-6-1 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)

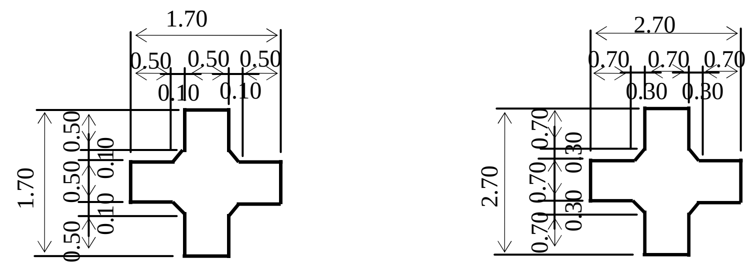


Fig. 2-2.3 Cast-in-place Concrete Block

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.

2-2-2-6-2 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 2-2.16 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 2-2.17 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 A（m^2）	1.70×0.30 = 0.51	2.70×0.30 = 0.81
Max. allowable velocity （m/sec）	6.0	7.5

2-2-2-6-3 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 2-2.18 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

2-2-2-7 Intake Facilities

2-2-2-7-1 Selection of Intake Method

There are ① intake weir method and ② the mountain stream intake method and ③ infiltration gallery method (wire-wound perforated pipe) as the intake methods at rapid stream. The comparative study shall cover raw water intake, the design flood, inflow sediment, dimension and safety of facilities, construction, and the economies as shown in Table 2-2.19.

As a result of comparative study, ① intake weir method is adopted by the following reasons. The flushing sluiceway is planned to be constructed in the intake works because the flushing sluiceway gate receives damage easily by the boulder stone at the flood and the gate operation at the flood is difficult when the flushing sluiceway is constructed in the river.

1) The intake weir method can utilize the main body of the existing intake fixed weir with repairing the surface by a surface protection work. Moreover, the safety of the intake weir can be secured by repairing energy dissipater type apron at the downstream of weir, riverbed protection and the revetment work which protects from the scouring of downstream riverbed.

2) In the intake weir method, construction remains at the small scale because it can utilize the existing intake weir to result in easier construction and lower cost.

3) In the intake weir method, measure to inflow sediment is possible according to the new construction of flushing sluiceway and grit chamber work and improvement of the intake entrance.

4) Problems of the intake weir method in the rapid stream include damage and operation of flushing sluiceway gate during flood, but these can be eliminated by constructing flushing sluiceway in the intake structure.

5) The mountain stream intake method is possible to adopt to the steep and narrow mountain stream like the geographical feature of the existing Bemos intake, however, it cannot utilize the existing intake weir because it needs a new large-scale fixed weir, the revetment work, and the grit chamber though intake of the raw water is preferable. Therefore, construction of the mountain stream intake method is not easy and the cost rises as compared with the intake weir method.

6) Although an infiltration gallery method has a high stability of the facility because of underground structure and no direct collision of the flood, there is some fear to be washed out by scouring. Moreover, infiltration gallery method cannot be adopted for the intake facilities because the large-scale buried intake pipe is required because of difficulty of collecting submerged water by underground pipe easy clogged and it makes construction difficult in the riverbed of the rapid stream, though it is not required to operate the gate and sluiceway.

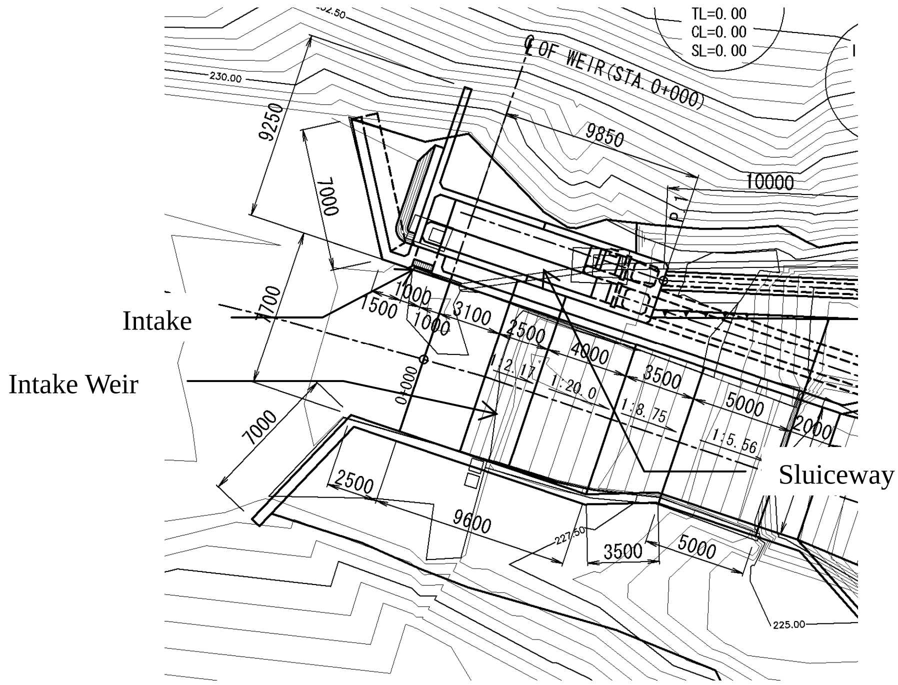
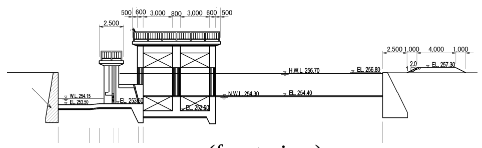
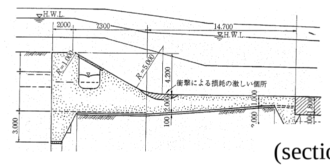
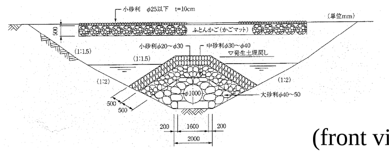


Fig. 2-2.4 Layout of Intake Facility

Table 2-2.19 Comparison of Intake Methods from Rapid Stream

Item	1) Intake weir method	2) Mountain stream intake method	3) Infiltration gallery method
sketch	 (front view)	 (section)	 (front view)
Intake of raw water	･Artificial maintenance of water route is needed. ･Water intake becomes impossible when water route cannot be induced to intake works. ･ It is necessary to adjust the intake discharge with the gate. (fair)	･ The necessary discharge of water intake is possible regardless of the situation of water route. ･ It is necessary to adjust the intake discharge with the gate or the valve. ･ (good)	･ The necessary intake discharge cannot be secured when there is no underflow water cut-off facility. ･ The necessary intake discharge cannot be secured when the collecting pipe filter occurs incrustation. (fair)
Design discharge	･ As the weir body, weir pillar, intake works, and the revetment work, etc. are constructed in the river, it is necessary to set an appropriate design flood discharge. ･ The flood water level goes up because of the construction of intake weir. (fair)	･ As the weir body and the revetment work, etc. are constructed in the river, it is necessary to set an appropriate design flood discharge. ･The flood water level goes up because of the construction of fixed weir. (poor)	･The influence on the flood doesn't reach though infiltration gallery is laid under the riverbed. (good)
Inflow sediment	･ The inflow sediment of the intake weir diversion weir without earth and sand Ha is numerous. ･The appropriate inlet and grit chamber are necessary for a measure of inflow sediment. (fair).	･ The inflow sediment at the flood can be reduced. ･The steep slope of collecting canal and the grit chamber are necessary for a measure of inflow sediment. (fair)	･The grit chamber is unnecessary because there are little inflow sediment. (good)

Item	1) Intake weir method	2) Mountain stream intake method	3) Infiltration gallery method
Scale of facilities	・Existing facilities can be used though a large-scale weir body, the intake works, and the revetment works are needed. (good)	・A large-scale fixed weir, the revetment works, and the grit chamber are needed. ・Existing facilities cannot be used. (poor)	・Necessary facilities are a large-scale infiltration gallery, the revetment and the riverbed protection, and it is not possible to adopt it by the steep stream. (not applicable)
Safety of facilities	・The gate and the weir body, etc. easily receive damage by the drift stones at the flood. (fair)	・The fixed weir etc. easily receive damage by the drift stones at the flood. (fair)	・The infiltration gallery method is danger for scouring and flowing out by flood flow. (poor)
Construction efficiency	・The construction of intake weir method is easy because not only the existing facilities can be used but also it requires only a small-scale repair. (good)	・The construction of mountain stream intake method is easy because there is no complex structure of flushing sluiceway. (fair)	・The construction of infiltration gallery method is difficult because the gallery is buried in the rapid stream where large rocks and big stones are dense. (poor)
Operation and maintenance	・The operation of the gates of the flushing sluiceway and the intake, and operation and maintenance for sand removal from the grit chamber etc. are necessary. (poor)	・The operation and maintenance for sand removal from the grit chamber etc. is necessary. (poor)	・The operation of the gates of the flushing sluiceway and the intake, and operation and maintenance for sand removal from the grit chamber etc. are unnecessary. (good)
Economic efficiency	・The cost is low because existing facilities can be used. (good)	・The cost is lower than the new intake weir method because there is no complex structure. (fair)	・AS necessary facilities are only infiltration gallery, revetment and riverbed protection, the cost is lower than the other method. (good)
Preference	(most applicable)	(poor)	(poor)

2-2-2-7-2 Selection of Apron Surface Protection Works

Wear-out and the damage of the weir body and apron concrete by flowing of the boulder stone and gravel are intense in the rapid stream. The concrete surface protection works which has results as a measures are ① the stone pitching method, ② the steel board pitching method, ③ the lamina elastic board pitching method, ④ the vacuum concrete method and ⑤ the high-strength concrete method. Table 2-2.20 shows the comparative study to abrasion resistance and impact, construction, and the economy.

As a result of the above comparative study, ⑤ the high-strength concrete method is adopted by the following reasons. The thickness of the high-strength concrete is assumed to be 0.5m which is the minimum thickness required for the apron in consideration of a big cobblestone and the boulder stone's flowing at the flood (Refer to the Head Works Design Standard of Ministry of Agriculture, Forestry and Fisheries).

1) The high-strength concrete method is a surface protection method which shows a lot of positive results in the rapid stream, and reliability is high though this method" is a little inferior in abrasion resistance and an impact compared with the stone pitching method, the steel board pitching method, and the lamina elastic board pitching method.

2) The high-strength concrete method is the lowest cost among other methods and its construction efficiency is similar to others though the high-strength concrete usually becomes rich mix proportion compared with normal concrete.

3) "Stone pitching method" is excellent in abrasion resistance and an impact, and it is easy to find good quality stone around sites, but there is scarce adoption for intake weir apron surface protection work in the rapid stream while this method is generally applied to the canal wall and revetment.

4) The steel board pitching method and the lamina elastic board pitching method are excellent in abrasion resistance and against an impact but its construction is not easy and the cost is very high. Further, it is difficult to procure material and equipment for those methods in Timor-Leste.

5) The vacuum concrete method is inferior in abrasion resistance and an impact compared with other methods, and special vacuum processing is needed for construction though the cost is lower than others.

Table 2-2.20 Comparison of Apron Surface Protection Works

Item	① Stone pitching method	② Steel board pitching method	③ Lamina elastic board pitching method	④ Vacuum concrete method	⑤ High-strength concrete method
Outline	• Ashlar masonry, quarry masonry etc. are used from the past. • Good quality stones and the skilled masons are needed.	• It is a method to anchor the steel board to the lower layer concrete and to fix surroundings by the welding. • The steel board and the lower layer concrete is separated for the temperature stress, and the steel board becomes a wave-like easily because of cobblestone and drift stone's impacts.	• It is a method to fix the elastic board of the polyurethane to the lower layer concrete with the anchor bolt etc. • There is a difficult point in jointing with the lower layer concrete, and construction is not easy.	• It is a method that sucks out the inside water of concrete from the surface by the vacuum processing at once after concrete is placed, and improves a concrete quality. • The special vacuum processing machine and the skilled engineer are needed though concrete strength improves by 20 to 30%.	• The fine aggregate is reduced with the rich mix proportion concrete that reduces the water-cement ratio. • It is necessary to execute the surface finishing works deliberately though the construction is usually similar to normal concrete.
Wear resistance	• This method is excellent for wear resistance because the stone pitching reacts to the abrasion of cobblestones and drift stones. (good)	• This method is excellent for wear resistance because the steel board reacts to the abrasion of cobblestones and drift stones. • However, the salient of steel board, which becomes waveforms by the impacts of cobblestone and drift stones, is partially worn-out when the thickness of the steel board is insufficient. (fair)	• This method is excellent for wear resistance because the lamina elastic board, which has an large energy-absorbing effect, reacts to the abrasion of cobblestones and drift stones. (good)	• Concrete strength improves by 20 to 30%, and the wear resistance also increases the same amount. • This method can not expect a good effect against the abrasion of cobblestones and drift stones. (poor)	• Concrete strength improves about 65%, and the wear resistance also increases the same amount. • This method expects a good effect against the abrasion of cobblestones and drift stones. (fair)
Impact resistance	• This method is excellent for impact resistance because the stone pitching reacts to the impact of cobblestones and drift stones.	• This method is excellent for impact resistance because the steel board resists against the impact of cobblestones and drift stones.	• This method is excellent for impact resistance because the lamina elastic board, which has an large energy-absorbing effect, reacts to the impacts of	• Concrete strength improves by 20 to 30%, and the impact resistance also increases the same amount. • This method can not	• Concrete strength improves about 65%, and the impact resistance also increases the same amount. • This method can

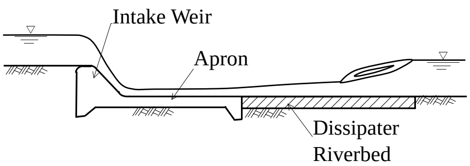
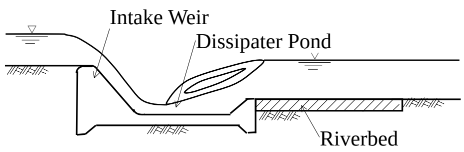
Item	① Stone pitching method	② Steel board pitching method	③ Lamina elastic board pitching method	④ Vacuum concrete method	⑤ High-strength concrete method
Impact resistance	• There is a problem of flaking off from the under layer concrete by the impact of the stones. (good)	• However, when the thickness of the steel board is insufficient, the board becomes waveforms easily because of the impacts of cobble stones and drift stones. (fair)	cobblestones and drift stones. (good)	expect a good effect against the impacts of cobblestones and drift stones. (poor)	expects a good effect against the impacts of cobblestones and drift stones. (fair)
Construction efficiency	• It is necessary to obtain good quality stone materials. • It is necessary to procure the skilled mason. The procurement of skilled mason is difficult also in Japan. (not applicable)	• It is necessary to fix the steel board to the under layer concrete with enough anchors. • It is not easy because a lot of the welding works are required. (poor)	• The lamina elastic board is fixed to the under layer concrete by anchors. • The construction is not easy because it is difficult to bond the board and the under layer concrete. (good)	• The special vacuum processing machine is needed. • The skilled engineer is needed for the vacuum processing of concrete. (poor)	• It is necessary to do the surface finish deliberately though construction method is usually similar to ordinary concrete works. • It is necessary to notice for curing of the concrete after placing because the crack might be occurred for the rich mixture concrete in the cold areas. (good)
Economic efficiency	• The procurement of skilled masons is difficult also in Japan though good quality stones procured in local can be used. (not applicable)	• To prevent the impacts of cobblestone and drift stones, a thick steel board is needed. • The cost is very high. (poor)	• To prevent the impacts of cobblestone and drift stones, a thick lamina elastic board is needed. • The cost is very high. (poor)	• The vacuum processing expense is usually bulky compared with ordinary concrete work. • Costs are lower than the methods mentioned to 1) to 3). (good)	• The amount of an increase of cement cost is usually bulky compared with ordinary concrete work. • Costs are lower than the methods mentioned to 1) to 3). (good)
Preference	(not applicable)	(poor)	(poor)	(poor)	（most applicable）

2-2-2-7-3 Selection of Overflow Type Energy Dissipater

There are ① the energy dissipater method by riverbed protection (many experience in Japan) and ② the energy dissipater method by pond (energy dissipater of waterfall type, many experience in many other countries) as the overflow type energy dissipater method of intake weir. The energy dissipater method by riverbed protection was adopted in Dili Water Supply Rehabilitation and Improvement Project for East Timor Implementation Facility (2000 ~ 2003). Table 2-2.18 shows the comparative study of dimension, safety, construction, management, the control and maintenance, and the economy of facilities.

As a result of comparative study, ② the energy dissipater method by pond is adopted by the following reasons.

Table 2-2.21 Comparison of Overflow Type Energy Dissipater Method of Intake Weir

Item	1) Energy dissipater method by riverbed protection	2) Energy dissipater method by pond
sketch		
Safety of facility	• As the flow energy can not be dissipated in the mountain stream and rapid stream, this method is not possible to apply. • As the flow energy is gradually dissipated on the flat and long riverbed protection, the danger such as scouring etc. is low. • It is necessary to plan an appropriate scale riverbed protection (type, length, and weight). (poor)	･As the flow energy is dissipated in the dissipater pond by compulsion, it is possible to apply with the mountain stream and rapid stream, ･Moreover, the danger of the worn-out of the apron and the outflow of the foundation of the riverbed protection is high. ･the decreasing energy can be done when appropriate depth to energy dissipater method by pond can be secured and safety is high. (better)
Construction efficiency	･Construction efficiency is good though the facility spreads flatly. ･The drain during construction is easy because it is settled with plan of a shallow structure. (better)	･Construction efficiency is low because it becomes a deep structure. ･Moreover, the drain during construction becomes large-scale. (poor)
Operation and maintenance	• As a rapid flow passes on the riverbed protection, scouring and wear for the protection might be occurred. It is required to maintain the facility appropriately. (poor)	• As the flow energy can be dissipated in the dissipater pond, it is required for an appropriate concrete surface protection works to protect from the wear by drift stones and gravel. (better)
Economic efficiency	• This method cannot be applied, because the riverbed protection works in the rapid stream cannot dissipate energy. (poor)	• The cost becomes low because it is good in short riverbed protection though deep energy dissipater pond is needed. (better)
Preference	(poor)	(better)

1) The basic concept of the overflow type energy dissipater method is to decrease the flood

energy safely from a high velocity flood of supercritical flow to a low velocity flood of subcritical flow. The flood condition of the Bemos river at the intake weir point is a rapid stream with riverbed slope as steep as about 5% and the flow is very fast. It is deemed impossible to dissipate the energy by ① the energy dissipater by riverbed protection in the rapid stream like Bemos river.

2) It is possible to apply with mountain stream and rapid stream by the energy dissipater in the pond by compulsion. Moreover, the decreasing energy can be done when appropriate depth to the energy dissipater method by pond can be secured with enough safety.

3) The energy dissipater method needs an appropriate apron surface protection work because the danger of the worn-out of the pond apron is high.

4) The energy dissipater method is easy for control and maintenance because of easier energy dissipating in the pond though its construction efficiency is inferior because it requires a deep structure causing large-scale drain facility during the construction.

5) Riverbed protection can be shortened and the cost becomes lower, though the energy dissipater by pond method needs deep pond.

2-2-2-7-4 Main Body of Intake Weir

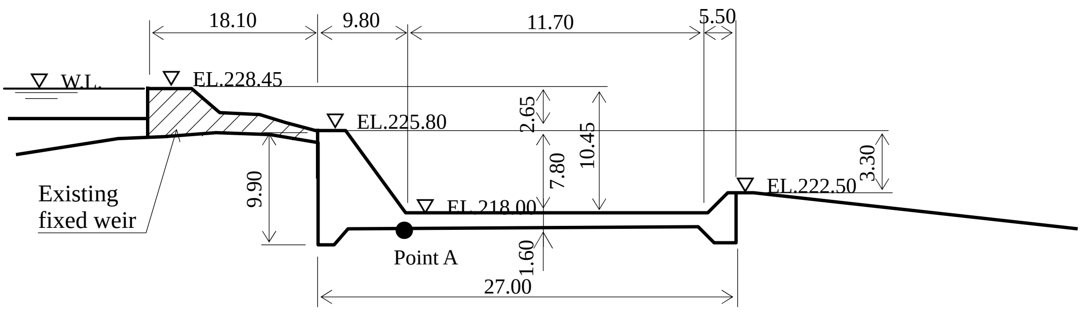


Fig. 2-2.5 Longitudinal Section of Intake Weir

(1) Fixed Weir Body

The downstream riverbed of the existing fixed weir was excavated by scouring by overflow for about 3.30m in depth. In case that the apron with the energy dissipator method by pond is adopted in order to dissipate the energy of overflowed water through the weir, the crest of the new fixed weir becomes as high as 7.80m. To secure the stability of the weir at the normal dam-up or the floods with the earth pressure acted on the weir crest (the altitude: EL.225.80m), the slope of the downstream side of the weir is to be examined. According to the actual examples of weir design and construction in Japan, the slope of upstream side of weir is of perpendicular and the downstream side is fixed at a slope of 1:1.0.

Moreover, the edge of downstream of the existing weir has been scoured in the range of 2.0m in depth, 5.8m in height and about 8.5m in width. As the portion scoured is very important for the base of the downstream of the weir, it will be backfilled by a coarse aggregate concrete (strength 18N/mm^2) which should be required to be impermeable and no settlement.

The surface of concrete of the existing weir has been worn-out and damaged by a large amount of debris flow mixing with boulders during the floods. As a result of comparative study on 2-2-2-7-2, the durability of the concrete surface on the existing and new weirs is to be secured by adopting “High-strength concrete method (0.5m in thickness)” as a surface protection method.

(2) Downstream Apron of the Intake Weir

As the downstream riverbed is in danger of scouring from overflow on the weir, a downstream apron of the intake weir is designed to protect the downstream riverbed from scouring. The length and the thickness of the apron and a creep length are planned by “Headworks design standard of Ministry of Agriculture, Forestry and Fisheries, Japan”

① **Length of the Downstream Apron**

The length of the downstream apron is determined by the intake water height and the conditions of the foundation (Refer to the headworks design standard).

② **Creep Length**

It is necessary to secure a creep length along the weir foundation and the rear of the retaining wall for the prevention of piping. The creep length required should adopt the bigger numerical value calculated by the Bligh’s method and the Lane’s one (Refer to the headworks design standard).

There is no danger of piping for the existing weir because it sticks firmly to the bedrock. The new fixed weir added to the downstream requires examining the prevention of the piping because it is to be constructed on the gravel layer.

③ **Thickness of the Downstream Apron**

The thickness of the downstream apron is determined from a formula for the balance of uplift (Refer to the headworks design standard).

④ **Apron of Energy Dissipater Method by Pond**

The overflow energy dissipator method adopts "energy dissipator method by pond" since it makes comparative study by 2-2-2-7-3. For the supercritical flow at the toe of the weir takes place to energy dissipation as a hydraulic jump, the altitude (EL.218.00m) of the apron bottom has to satisfy that the downstream water level (H.W.L.224.35m) of the weir should be higher than the sequent water level (W.L.224.11m) to the supercritical flow.

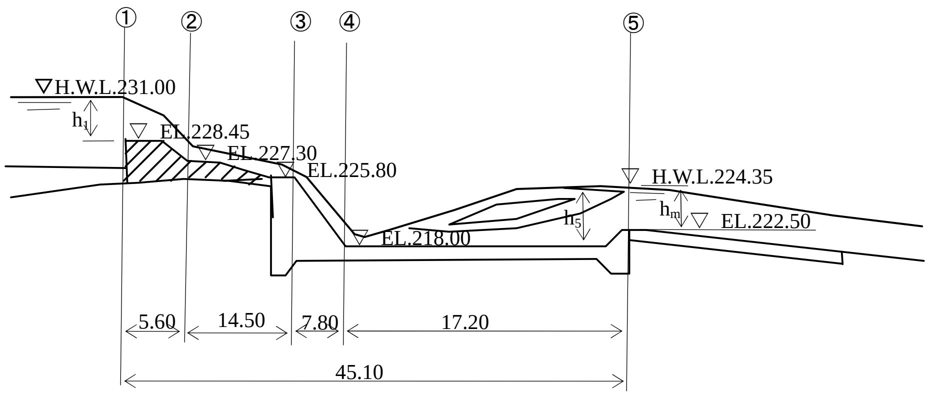


Fig. 2-2.6　Downstream Water Level of the Intake Weir at the Design Flood Level

(3)　Downstream Riverbed Protection at the Intake Weir

①　Length of Downstream Riverbed Protection

The overflow on the weir dissipates at the energy dissipator basin. The riverbed protection length of the energy dissipator basin type apron shall extend up to the downstream edge of a hydraulic jump swirl (Refer to the headworks design standard).

②　Type and Weight of Downstream Riverbed Protection

The type and the weight of the downstream riverbed protection are selected from Table 2-2.18 in the section 2-2-2-6.

(4)　Design Parameter of Main Body

The design parameter is decided from the design result of the main body of the intake weir as shown in the table below (refer to Appendix 5-2).

Table 2-2.22　Design Parameter of Main Body of the Intake Weir

Design Item	Design condition	Required parameter	Design parameter	Remark
1. new fixed weir body	Water level difference: H = 3.30m	Upstream slope; vertical downstream slope; 1 : 1.0	Upstream slope; vertical downstream slope; 1 : 1.0	・refer to the examples in Japan and Timor-Leste
2. length of downstream apron	Intake water height: H = 10.45m Coefficient of Bligh: （gravel） C = 6	Length required: la = 11.64m	Design Length : la = 11.70m	・to secure the length of apron for overflow ・to secure the creep length
3. creep length	Water level difference: ⊿H = 3.30m Coefficient of Bligh: C = 6 Coefficient of Lane: C' = 2.5	Bligh's method: S = 19.80m Lane's method: L = 8.25m	Bligh's method: S = 38.40m Lane's method: L = 20.40m	・to adopt the downstream apron length

Design Item	Design condition	Required parameter	Design parameter	Remark
4. thickness of downstream apron	Water level difference: ⊿H = 3.30m Head loss: Hf = 1.74m	Thickness required: ta = 1.54m	Design Thickness : ta = 1.60m	・to secure the thickness required for uplift
5. depth of energy dissipator basin	Max. Water level difference: Hm = 6.65m Flood discharge: Qf = 200m^3/sec	Depth required: D = 4.26m	Design depth: D = 4.50m	・to secure the downstream sequent depth to occur a hydraulic jump
6. length of protection	Flood discharge: q = 14.16m^3/s/m Intake water height :5.95m	Length required: L = 13.74m	Design Length: L = 15.00m	・5lines×@ 3.0m
7. riverbed protection block	Velocity: V = 7.20m/sec	Cast-in-place crossing type concrete block Allowable velocity: Va = 8.0m/sec	Cast-in-place crossing type concrete block Design weight: W = 8.0 t Width 2.7m × 2.7m × Height 1..0m	・to select the blocks available in Timor-Leste

2-2-2-7-5 Intake Works and Connecting Canal

(1) Intake Section

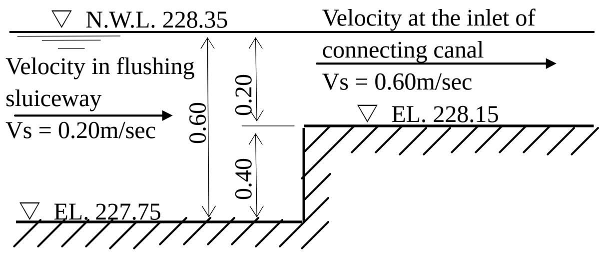


Fig. 2-2.7 Flushing Sluiceway and Threshold Elevation

① Design Intake Level

The design intake level, which is lower by 0.10m from the weir crest height (EL. 228.45m), is shown below.

・ Design Intake Level = EL. 228.45m – 0.10m
= N.W.L. 228.35m

② Sill Elevation of Flushing Sluiceway and the Intake Inlet Elevation of Connecting Canal

The majority of the flowing sediment in the flushing sluiceway is the tractable sand (rolling and flowing sediment in the riverbed) at the intake time. Therefore, the intake inlet elevation is raised by 0.40m higher than the sill elevation of flushing sluiceway so as to prevent the inflow of the sediment into the intake inlet of connecting canal. Moreover, to prevent the inflow of the sediment, water depth at the inlet is planned to be 0.20m, about 30% of the water depth in the flushing sluiceway.

・ Flushing sluiceway sill elevation = N.W.L. 228.35 – (0.40m + 0.20m) = EL. 227.75m
・ Inlet elevation = EL. 227.75m + 0.40m = EL. 228.15m

③ Intake Velocity and Inflow Velocity at the Intake Inlet of Connecting Canal

Flushing sluiceway is planned to connect with the intake inlet. The structure of the flushing sluiceway is designed to be able to drop the sediment which is bigger than the coarse sand of about

0.5mm as the velocity of 0.2m/sec in the flushing sluiceway at the intake time.

In general, to prevent the inflow of the sediment into the connecting canal, the inflow velocity standard at intake inlet is 0.6 to 1.0m/sec, however the velocity is decided to prevent the inflow of the sediment into long raw water main as follows.

- velocity at the intake inlet and in the flushing sluiceway = approximately 0.20m/sec
- inflow velocity at the inlet of connecting canal = approximately 0.60m/sec

④ **Width of Intake Inlet and the Flushing Sluiceway and Width of Intake Inlet of Connecting Canal**

The width of intake inlet, the flushing sluiceway and inlet of connecting canal are decided based on the following equations of continuity according to the inflow depth and the inflow velocity calculated from the sill elevation of the intake inlet and the design water level at intake.

(a) Width of Intake Inlet and the Flushing Sluiceway

$$Bs = Q / (hs \cdot Vs) = 0.102 / (0.60 \times 0.20) = 0.85\text{m} \fallingdotseq 1.00\text{m}$$

Where, Bs : width of intake inlet and the flushing sluiceway (m)

Q : design intake discharge, Q = 0.102 m^3/sec

hs : inflow depth, hs = N.W.L. 228.35m - EL. 227.75m = 0.60m

Vs : intake velocity, V = 0.20m/sec

(b) Width of Intake Inlet of Connecting Canal

$$Bi = Q / (hi \cdot Vi) = 0.102 / (0.20 \times 0.60) = 0.85\text{m} \fallingdotseq 1.00\text{m}$$

Where, Bi : Width of intake inlet of connecting canal (m)

Q : design intake discharge, Q = 0.102 m^3/sec

hi : inflow depth, hi = N.W.L. 228.35m - EL. 228.15m = 0.20m

Vi : intake velocity, V = 0.60m/sec

(2) Length of Flushing Sluiceway

① **Hydraulic Conditions**

Hydraulic conditions of grit chamber of flushing sluiceway are as follows.

- design flow capacity: Q = 0.102m^3/sec
- grain size for settling: d = 0.5-40.0mm (interval of mesh screen)
- velocity in the flushing sluiceway: V = 0.102 / ((0.60 – 0.30) ×(1.00 + 0.30 + 1.00) = 0.15m/sec
- effective water depth in the flushing sluiceway: taking into account the depth of 0.30m of sediment, hs = 0.30m

② **Examination of Flushing Sluiceway**

- effective width of flushing sluiceway: Bs = 1.00 + 0.30 + 1.00 = 2.30m
- effective depth in flushing sluiceway: hs = 0.60 – 0.30m = 0.30m
- velocity in flushing sluiceway: Vs = 0.102 / (2.30 × 0.30) = 0.15 m/sec
- critical settling velocity: Vg = 0.01 m/sec (against the min. grain size: d_{min}. = 0.2mm)

The length of flushing sluiceway is obtained by the following formula.

Ls = K・hs/Vg・Vs = (1.5～2.0) × 0.30/0.01 × 0.15 = 6.75m～9.00m

Where,
L : length of sedimentation ditch (m)
K : safety factor, K = 1.5～2.0
h : effective water depth, h = 0.30m
Vg : critical settling velocity, Vg = 0.01m/sec (min. grain size: d_{min}. = 0.2mm)
V : velocity in flushing sluiceway, V = 0.15m/sec

Therefore, the length of flushing sluiceway is 7.0m.

(3) Intake Inlet and Connecting Canal

As there is danger that the fallen leaves from the mountainside enter into the connecting canal which is planned along the left bank side, the canal is to be a flume type with concrete lids in consideration of easy maintenance. Moreover, the connecting canal crossing work with concrete box culvert (Width 1.0m ×height 1.2m ×length 11.45m) type is planned for draining water from the stream at the Sta. 0 +050 swamp in 050 points.

① **Intake Inlet of Connecting Canal**

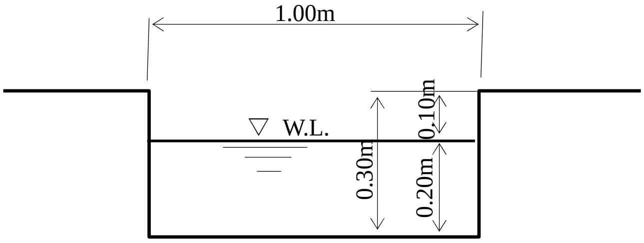


Fig. 2-2.8 Section of Intake Inlet of Connecting Canal

➢ Hydraulic parameters of Intake inlet of connecting canal

- design discharge: Q = 0.102m^3/sec
- design water level: N.W.L. 228.35m – 0.30m = W.L. 228.05m
- width of intake inlet: B = 0.600m
- intake water depth: h = 0.200m
- cross-sectional area of flow: A = 1.00 ×0.20 = 0.200m^2
- intake velocity: V = 0.102 / 0.200 = 0.510m/sec ≦ 0.60m/sec
- velocity head: hv = 0.510^2 / (2 ×9.8) = 0.013m
- freeboard: Fb = 0.07 ×0.20 + 0.013 + (0.05～0.15) = 0.077m～0.177m

- height of side wall: $H = 0.200 + (0.077 \sim 0.177) = 0.277 \sim 0.377 = 0.300m$

② Connecting Canal

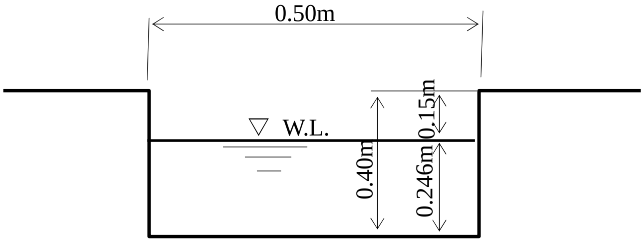


Fig. 2-2.9 Cross Section of Connecting Canal

➢ Hydraulic parameters of connecting canal

- design discharge: $Q = 0.102m^3/sec$
- design water level: W.L. 228.05m – 0.05m = W.L. 228.00m
- width of connecting canal: $B = 0.500m$
- connecting canal slope: $I = 1/400$
- roughness coefficient of canal: $n = 0.015$
- water depth of connecting canal: $h = 0.246m$
- cross-sectional area of flow of connecting canal: $A = 0.500 \times 0.246 = 0.123m^2$
- wetted perimeter of connecting canal: $P = 0.500 + 2 \times 0.246 = 0.992m$
- hydraulic radius of connecting canal: $R = 0.123 / 0.992 = 0.124m$
- velocity of connecting canal: $V = 1/0.015 \times 0.124^{2/3} \times (1/400)^{1/2} = 0.829m/sec \leqq 3.00m/sec$
- velocity head of canal: $hv = 0.829^2 / (2 \times 9.8) = 0.040m$
- Froude number: $Fr = 0.829 / (9.8 \times 0.246)^{0.5} = 0.534 \leqq 0.54$
- critical friction velocity: $U^* = (980 \times 0.124 \times 100 \times 1/400)^{0.5} = 5.512cm/sec$
- critical migration grain size : $dmax = 5.5122 \times 10 / 80.9 = 3.8mm$
- freeboard of canal: $Fb = 0.07 \times 0.246 + 0.040 + (0.05 \sim 0.15) = 0.107m \sim 0.207m$
- height of side wall of canal: $H = 0.246 + (0.107 \sim 0.207) = 0.353 \sim 0.453 = 0.400m$

2-2-2-7-6 Grit Chamber

A large amount of sediment, gravel, and the fallen leaves, etc. flow into the raw water main in the existing facilities and the frequency to suspend water supply increases because of the necessity for control and maintenance causing the difficulty in operation. The second grit chamber is to be newly constructed as additional inflow sediment measures, though the flushing sluiceway (first grit chamber) be constructed newly as an annex to the intake works to reduce the inflow of sediment and gravel.

The policy to the new construction of grit chamber is planned as follows.

1) The design of the grit chamber conforms to "Design Criteria for Waterworks Facilities by Japan Water Works Association (2000)" and "Head Works Design Standards of Ministry of

Agriculture, Forestry and Fisheries".

2) Design discharge is $Q=0.102m^3/sec$.
3) The particle size of the settling sand is assumed to be a level of fine sand (0.2mm) to screen intervals (50.0mm).
4) The standard velocity of the grit chamber is 0.15 m/sec that can settle minimum grain diameter of 0.2mm.
5) The standard of effective depth of the grit chamber is set (h = 0.50m) which is about the twice of the connecting canal depth.

(1) Effective Water Depth and Width of Grit Chamber

Effective water depth and width of the grit chamber are as follows.

・effective water depth of the grit chamber: About double of water depth of the connecting canal is assumed. Approximately h = 0.50m
・effective width of the grit chamber: $B = 0.102 / (0.15 \times 0.50) = 1.36m ≒ 1.50m$
・velocity in the grit chamber: $V = 0.102 / (1.50 \times 0.50) = 0.136$ m/sec
・critical dropping velocity: Vg = 0.01 m/sec（against the min. grain size: d_{min}. = 0.2mm）

(2) Length of Grit Chamber Ditch

The length of the grit chamber ditch is obtained by the following formula.

$$L = K \cdot h/Vg \cdot V = (1.5\sim2.0) \times 0.50/0.01 \times 0.136 = 10.2\text{-}13.6 \text{ m}$$

Where, L : length of grit chamber ditch（m）
K : safety factor, K = 1.5～2.0
h : effective water depth, h = 0.50m
Vg : critical dropping velocity, Vg = 0.01m/sec（min. grain size: d_{min}. = 0.2mm）
V : velocity in the grit chamber, V = 0.136m/sec

Therefore, the length of the ditch is assumed to be 12.0m.

(3) Design of Spillway

① Discharge at the Full Flow of the Connecting Canal and Spill Water Volume

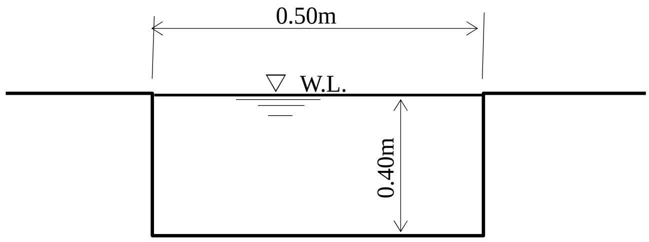


Fig. 2-2.10 Cross Section of Connecting Canal

➢ Hydraulic parameter at the full flow of the connecting canal

- width of connecting canal: B = 0.50m
- connecting canal slope: I = 1/400
- roughness coefficient of connecting canal: n = 0.015
- water depth of connecting canal: h = 0.40m
- cross-sectional area of flow of canal: A = 0.50 × 0.40 = 0.20m^2
- wetted perimeter of connecting canal: P = 0.50 + 2 × 0.40 = 1.30m
- hydraulic radius of connecting canal: R = 0.20 / 1.30 = 0.154m
- velocity of connecting canal: V = 1/0.015 × $0.154^{2/3}$ × $(1/400)^{1/2}$ = 0.96m/sec
- velocity head: hv = $0.96^2/(2 \times 9.8)$ = 0.047m
- Froude number: Fr = $\frac{0.96}{\sqrt{9.8x0.40}}$ = 0.48
- discharge at the full flow: Q_{max} = 0.20 × 0.96 = 0.138m^3/sec

➢ Spill water volume of spillway: Qs = 0.138 – 0.102 = 0.036m^3/sec

② **Overflow Length of Spillway**

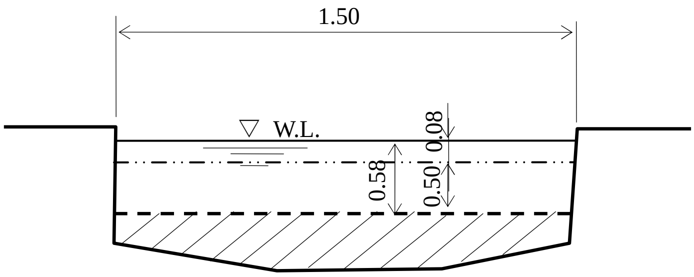


Fig. 2-2.11 Cross Section of Grit Chamber

➢ Hydraulic parameter of upstream end of spillway

- discharge: Q_1 = 0.138m^3/sec
- width of grit chamber: B_1 = 1.50m
- water depth: h_1 = 0.58m
- cross-sectional area of flow: A_1 = 1.50 × 0.58 = 0.87m^2
- velocity: V_1 = = 0.138 / 0.87 = 0.16m/sec
- velocity head: $hv_1 = 0.16^2 / (2 \times 9.8)$ = 0.001m
- Froude number: Fr_1 = $\frac{0.16}{\sqrt{9.8x0.58}}$ = 0.07
- overflow depth: H_{e1} = 0.08m

➢ Hydraulic parameter of downstream end of spillway

- discharge: Q_2 = 0.102m^3/sec
- width of grit chamber: B_2 = 1.50m
- water depth: h_2 = 0.50m
- cross-sectional area of flow: A_2 = 1.50 × 0.50 = 0.75m^2

- velocity: V_2 = = 0.102 / 0.75 = 0.136m/sec
- velocity head: $hv_2 = 0.136^2 / (2 \times 9.8) = 0.001$m
- Froude number: $Fr_2 = \dfrac{0.136}{\sqrt{9.8x0.50}} = 0.06$
- overflow depth: $H_{e2} = 0.00$m

➢ Overflow length of spillway

$Q_w = C \cdot L \cdot H_{em}^{3/2}$

Where, Q_w : overflow discharge of spillway（m³/sec）

L : overflow length of spillway, assumed as 3.00m

Hem : average overflow depth, Hem = 1/2×(0.08 + 0.00) = 0.04m

He1 : overflow depth at the upstream end of spillway,He1 = 0.08m

He2 : overflow depth at the downstream end of spillway, He2 = 0.00m

C: coefficient of overflow, $C = 1.838 \times (1+0.0012/Hem) \times (1 - \dfrac{\sqrt{Hem/L}}{10})$

= 1.82

$Q_w = 1.82 \times 3.00 \times 0.04^{3/2} = 0.044\text{m}^3/\text{sec} > 0.036\text{m}^3/\text{sec}$

Therefore, the overflow length of the spillway is given as 3.00m.

③ Weight of Outlet Sand Flush Chamber

The weight of outlet sand flush chamber which is not flushed away at the flood is given as the following formula.

$W > 3.75 \cdot A \cdot V^2 / 2\,g$

Where, W : weight of block（tf/piece）

A : area of the impact of flow, A = 3.20m × 0.30m = 0.96m²

V : velocity at the impact of flow against the block, V = 7.20m/sec

g : acceleration gravity, g = 9.80m/sec²

$W > 3.75 \times 0.96 \times 7.20^2 / 2 \times 9.8 = 9.52$ tf/ piece

Therefore, the scale of outlet sand flush chamber is assumed to be 2.50m × 2.50m × 0.50m（weight: 13.67tf/piece).

2-2-2-7-7 Revetment

Based on the section 2-2-2-5 Selection of Revetment, the type of revetment of intake facility is selected as shown in the Table below.

Table 2-2.23 Selection of Revetment of Intake Facility

Item of revetment	Velocity at dominant discharge (m/sec)	Height of revetment (m)	Slope gradient	Type of retaining wall	Max. allowable velocity (m/sec)
Upstream revetment	5.15	2.10	1 : 0.0 (vertical)	gravity type retaining wall	6.0
Revetment of weir body	9.44 × 0.8 = 7.55	2.40	1 : 0.0 (vertical)	Reversed T type retaining wall	9.0
Revetment of downstream apron	14.91 × 0.8 = 11.93	7.80	1 : 0.0 - 0.5	Reversed T type retaining wall	12.0
Downstream revetment	5.79 × 1.2 = 6.94	4.00	1 : 0.5	Wet masonry (depth approx. 50cm)	7.0

Note) 1. As there is no space in the back, the slope gradient of revetment of upstream and weir body is fixed as 1:0.0 (vertical) .
2. The velocity of the revetment of weir body and the downstream apron at the control discharge is adopted to be 80% taking into account the lateral position.
3. Considering the influence of hydraulic jump, the velocity of the downstream revetment is adopted to have an increase by 20%.
4. As it exceeds the maximum allowable velocity of 6.0m/sec at the reversed T type retaining wall of the revetment of weir body, the reinforcement covering is adopted to be 6.5cm having an increase of 1.5cm on the standard of 5.0cm.
5. As it exceeds the maximum allowable velocity of 9.0m/sec at the reversed T type retaining wall of the downstream revetment, the reinforcement covering is adopted to be 8cm with an increase by 3cm on the standard of 5.0cm.

2-2-2-8 Raw Water Main

2-2-2-8-1 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 2-2.24. The quality of GSP is required to be equal to the carbon steel pipes (JIS

G 3452) or higher.

Table 2-2.24 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 2-2.25 and Fig. 2-2.12 schematic diagram below.

Table 2-2.25 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.											82.2
(DIP φ 300)	DIP	0.0764	5.055	300	1	0.0764	130	1.081	3.957	20.002	
2 No.7 + 62.00											102.2
(SGP φ 300)	SGP	0.0764	0.237	300	1	0.0764	100	1.081	6.429	1.524	
3 No.6 + 900.00 (Branching Point)											103.7
(SGP φ 300)	SGP	0.1019	5.472	300	1	0.1019	100	1.442	10.953	59.936	
4 Break Pressure Tank											163.7
5 Break Pressure Tank											169.5
(SGP φ 250)	SGP	0.1019	1.287	250	1	0.1019	100	2.076	26.617	34.256	
6 Bemos Intake											203.8
											(< Grit Chamber 227.65m)
7 Bemos W.T.P.											101.5
(SGP φ 200)	SGP	0.0225	0.300	200	1	0.0225	100	0.716	4.825	1.448	
3 No.6 + 900.00 (Branching Point)											102.9
											(< 103.7m)

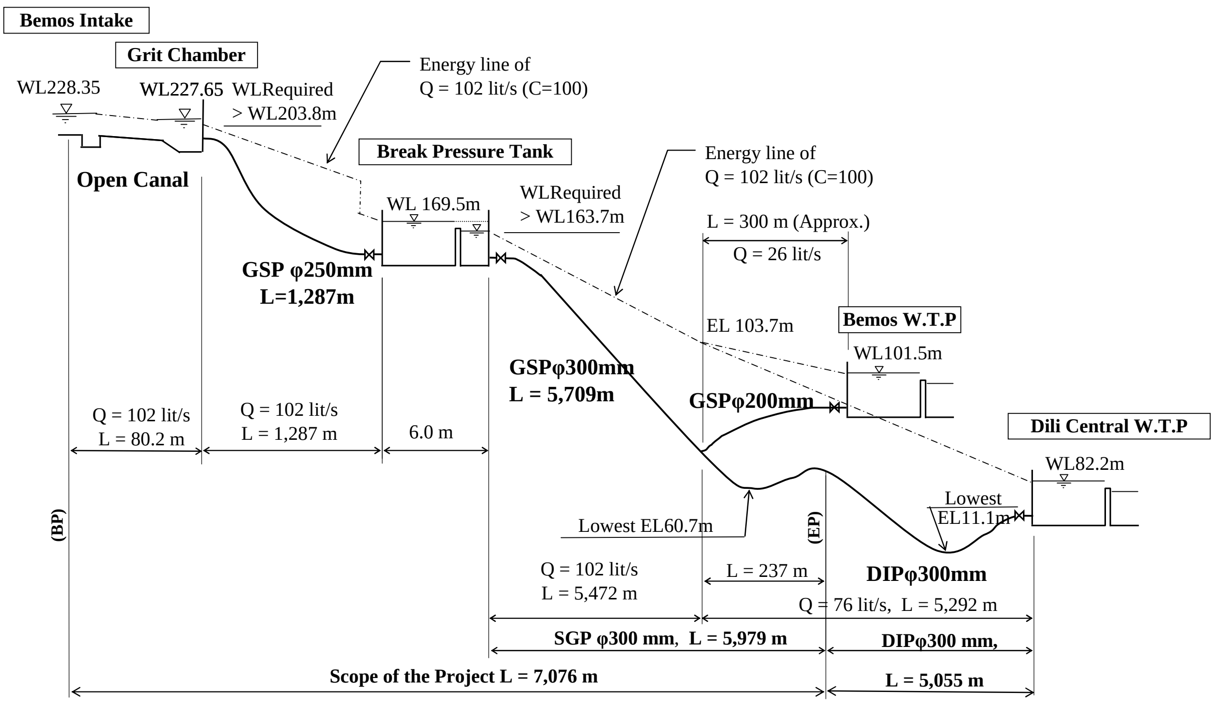


Fig. 2-2.12 Schematic Hydraulic Profile of the Bemos Raw Water Main

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 58.15m (=W.L.227.65m-W.L.169.5m), and the design has the head of about 22m 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 85.6m against the effective head of 87.3m (= W.L.169.5m-W.L.82.2m), so the design has the head of about only 1.7m 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 2-2.26 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 2-2.27 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. 2-2.13.

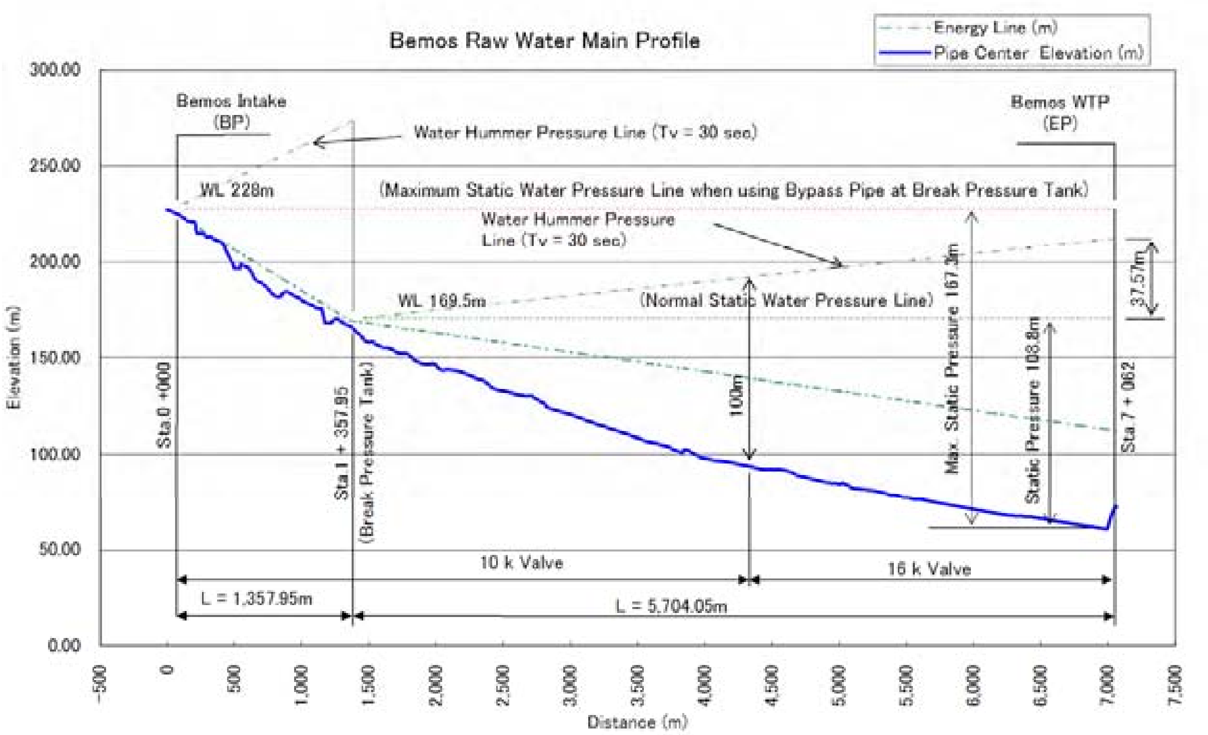


Fig. 2-2.13 Hydraulic Pressure of Bemos Raw Water Main

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.

From 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.

From the above-mentioned calculation results, it is assumed that the maximum internal water pressure of about 15kgf/cm2 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.

2-2-2-8-2 Study on Pipeline Alignment of Raw Water Main

Judging from the site survey result concerning with the rehabilitation of the raw water main, the sections where the comparative study are necessary between the rehabilitation of the existing one and the route change are shown as follows together with the comparative study result.

(1) Rehabilitation Structure No.5: Riverside Terrace of Right Bank, Tributary Crossing part and Abutment of Existing Retaining Wall （Sta.0 + 584.16 (IP.19) ～ Sta.0 + 742.38 (IP.22)）

As for the condition of the existing buried pipes, the river terrace exposes pipes by scouring about 23m long and is pending at the flood in a station concerned. Moreover, 20m in the branch crossing part section of the downstream is concrete covering, and about 0.4 m of concrete covering at the downstream side is scoured. There is a possibility of breakage of the pipes by boulder stone etc. if the scour by such as floods is advanced on the pipes as it is.

As for the comparison plan, the following two plans are considered.

Plan-1: The exposed portion of the existing route is protected by the wet masonry revetment and the branch crossing part is protected by channel works composed of groundsill, riverbed protection and the wet masonry revetment. Moreover, the tributary of the Bemos river that is the confluence part with the Bemos river is planned with the revetment work at upper and lower parts of the Bemos river as a confluence works.
(Refer to Appendix 5-6, Fig- 1-1 and Fig 1-2)

Plan-2: The mountain side of the existing pipeline laid upstream and downstream of Bemos river at the confluence point of right bank tributary extends a smooth river terrace, and steady geographical features where the scouring doesn't reach by the flow of the Bemos river and the tributary. It is the route of exposure pipe of an existing pipeline and an old pipe has been flawlessly left as it is, too. Therefore, the route is shifted to the right bank mountain side by applying substitution pipeline from the upstream of the existing exposure part, crossing the tributary by aqueduct in a short span, and it is to be connected with the existing pipeline at an appropriate position of the downstream. Up and downstream portions of the aqueduct crossing in the tributary will be protected by the flow path structure composed of a wet masonry revetment and a riverbed protection works at a bottom.
(Refer to DWG. 11, 12, 13 in the section of 2-2-3 Basic Design Drawings)

As a result of the comparative study of above-mentioned two plans, Plan -2 is estimated with construction cost of about 89% and economical when compared with the Plan-1. Moreover, Plan-2 is advantageous in the maintenance point of view because the maintenance facility like washout chamber, sluice valve chamber and air valve chamber are newly established in the Plan-2. Therefore, Plan-2, "Route change and aqueduct in right bank tributary crossing" is adopted in repairing the Structure No.5.

(2) Rehabilitation Structure No.10 : Rehabilitation of Existing Route of Left Bank and Route Change Idea to Right Bank Riverside Terrace（Sta.1 + 400 ～ Sta.2 + 350）

The erosion still progresses though the riverside protection work is given with the gravity type retaining wall, so that the Bemos river may directly erode the pipeline base immediately in about 100m section at the downstream of the break pressure tank. Moreover, the protection work has been damaged at several places in about 500m at the downstream by piling up of the mud flow and the erosion. In addition, the pipeline is exposed by the scouring in the river terrace in the downstream, and the pipe and the fifth air valve chamber are in the state of hanging in the air. It is necessary, therefore, to make comparative study on two ideas that are rehabilitation of existing pipeline and route change to the opposite bank (right bank side) about 950m in the section.

Plan-1: Rehabilitation of the existing pipeline, Rehabilitation plan includes the following three portions

- Most upstream one is rehabilitation structure No.10-1 of the existing downstream side concrete retaining wall (Sta.1 + 420 to 530). Pipeline exposed by the scouring, and the protection work to the rock fall is necessary. Moreover, the reinforcement of basement and prevention work for the scouring are planned because there is a fear of overturn by scouring foundation of retaining wall, though this section is a water colliding front by the curve of the Bemos river, and the river side of the pipeline is protected with the gravity type concrete retaining wall. (Refer to DWG.17 in the section 2-2-3 Basic Design Drawings)

- The second one is rehabilitation structure No.10-2 riverside terrace of Bemos river left bank (Sta.1 + about 938). The protection work to the revetment work and the rock fall in this station is planned because the conduit has been exposed and there is a fear of the pipe damage with the rock fall and also the stream reaches the pipeline at the flood. (Refer to DWG.18 in the section 2-2-3 Basic Design Drawing)

- The third one is rehabilitation structure No.10-3 river terrace of Bemos river left bank (Sta.2 + 094 to 200). As the river terrace under which the pipeline was laid and receives the scouring by flood in this section and the basement of the pipeline washed out, the pipe is hanged in the air over about 100m. The river terrace in the upstream and downstream might be washed out easily by the scouring due to the flood and the air hanging section increases further, and there is a fear of pipe breakage. Therefore, the protection of pipeline in this section is to be made by revetment works and route change to the river bed.

.Plan-2: The right bank of Bemos river which is the opposite bank of Sta. 1+400 to Sta.2+350 of the existing pipeline extends over a comparatively steady river terrace, and planned to have route change of the pipeline avoiding the rehabilitation of 3 existing pipelines included in Plan-1 above. Two river crossings in the Bemos river are necessary because it is connected with the existing pipeline in an upstream and the downstream of the changed pipe, though geographical features is generally smooth. Moreover, the slope protection and the tributary crossing works are necessary because the changed route crosses the tributary of the Bemos river at the middle of changed pipeline. The changed pipeline is assumed to have laying the same GSPφ300mm as the existing one and it is 915m in length being shortened by 35m as compared with the existing one. (Refer to Fig.2-1, 2-2 and 2-3 in the Appendix 5-6)

Result of the comparative study of above-mentioned two plans is that Plan-1 (Rehabilitation of existing pipelines in three places) requires construction cost of only about 37%, and is economical to comparison plan -2 (right bank transfer plan). Then, Plan -1 (Rehabilitation of existing pipelines in three places) is adopted.

(3) Rehabilitation Structure No.10-3: River Terrace of Bemos River Left Bank (Sta.2 + 094〜200)

As already mentioned above, the scouring progresses and there is a fear of pipe breakage because the basement of the pipeline would be washed out in this section if the pipeline is hanging in the air and left as it is. The plan to protect the current state pipeline of this section by the revetment works or transfer the route and buried under the riverbed be comparatively examined.

Plan-1: The existing pipe exposed is protected by wet masonry revetment at lower part (revetment work of low water channel) and wet masonry revetment of upper part, and pipeline is covered by sand and gravel. Area of revetment covers not only existing exposed pipeline but also the parts receiving the scouring of an upper and lower portion, and the flood channel is protected by gabion in order to secure the foundation of the upper wet masonry revetment and prevent scouring with the stream. (Refer to Fig-3 in the Appendix 5-6)

Plan-2: The pipeline of 200m in length is shifted to river bed in the Bemos river including the portions of the existing exposed pipeline and of the high possibility of receiving the scouring in the upstream and downstream. The pipe laying method under the river bed in the Bemos river main channel adopts the same protection works as the river crossing one where pipe is protected by concrete encasement and above the pipe is protected by concrete block. Moreover, as the movement of the deepest part in the riverbed is expected, the upper surface of riverbed protection is planned to stay below the deepest riverbed of the Bemos river. New air valve, sluice valve and washout valve are planned in the connection point with the existing pipe at the downstream end of the shifted pipe. (Refer to DWG.19 in the section 2-2-3 Basic Design Drawing)

As the result of the comparative study of above-mentioned two plans, Plan -2 (Shifting route under the riverbed) is more economical than Plan-1 with the construction cost of about 95%. Moreover, Plan-2 is simple structurally, and it is excellent in stability of the basement and construction efficiency. Therefore, Plan-2 (Shifting route under the riverbed) is adopted.

2-2-2-8-3 Basic Design for Improvement of the Facilities

(1) Structure No.4: River Crossing No.1

① Raw Water Main

The Pipeline of the existing Raw Water Main is still soundly functioning, though the pipe and its protection concrete have no earth coverage. Accordingly, the existing pipeline itself will be utilized without any improvement. The earth coverage more than 2.0m in thickness is required in general to secure the safety of the existing pipe in future, which brings about 2.0m difference in height between up and downstream of the river crossing and also the groundsill with high drop is required. To avoid constructing such high drop groundsill, the pipe will be covered by the concrete apron with 0.5m in thickness instead of earth coverage of 2.0m to secure the safety of the existing pipe.

② Groundsill for Protection of Existing Pipe (Raw Water Main)

(a) Groundsill

The downstream riverbed of the existing river crossing has been scoured to 0.5m in depth. Under such riverbed conditions, the drop of the groundsill is estimated at 1.0m in case that the existing pipe is protected by the concrete apron with 0.5m in thickness. In order to secure the stability of the groundsill even in the flood together with receiving the full height earth pressure (up to the crest: EL198.60m), the side slopes are set vertical for upstream and 1: 0.5 for downstream based on the practical examples in Japan.

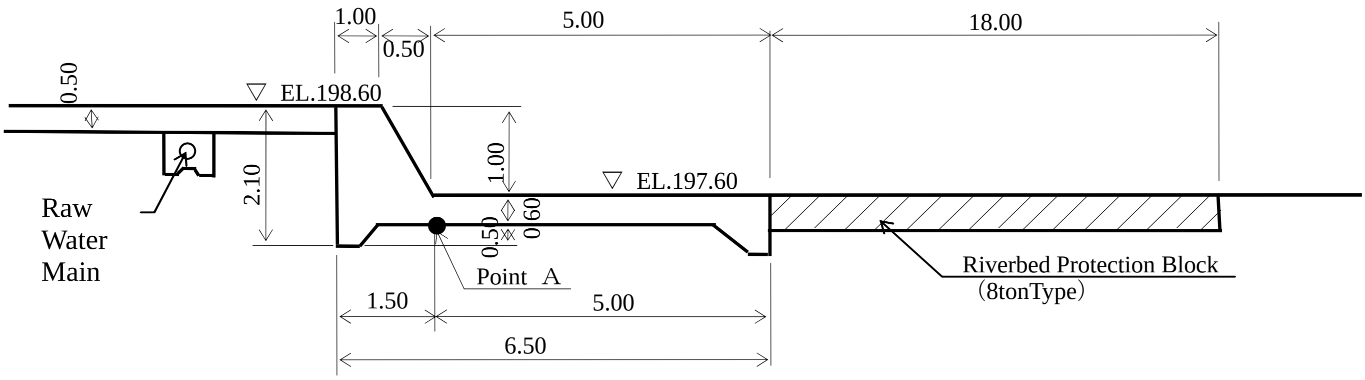


Fig. 2-2.14 Typical Section of Groundsill

(b) Downstream Apron

There are some risks of scouring the downstream riverbed by the drop water overflowing the groundsill so that the concrete apron is installed at the downstream of the groundsill to protect riverbed from scouring. The length of the apron is planned as follows based on the Head Works Design Standard of MOAFF (refer to Appendix 5-3).

1) Downstream Apron Length

The length of downstream apron is designed in consideration of groundsill drop and soil condition of foundation ground.

2) Creep Length

In order to prevent a piping of foundation, it is necessary to secure the enough creep length along the perimeter of groundsill and backside of a revetment. The creep length to be secured is selected with longer one between two figures calculated by the Bligh formula and the Lane formula.

3) Thickness of Downstream Apron

The thickness of the downstream apron is designed by the equation relevant to the balance of uplift pressure. The maximum uplift pressure will be given at the point A indicated in the above figure which will give the maximum thickness of the downstream apron.

4) Downstream Riverbed Protection

a) Length of Riverbed Protection

Drop water energy after overflowing the groundsill is dissipated through the downstream apron and riverbed protection. Required length of the downstream riverbed protection is given by the experimental Bligh formula.

b) Type and Weight of Downstream Riverbed Protection

Type and the weight of the downstream riverbed protection is selected based on the Table 2-2.18 Applicable Condition, in the section 2-2-2-6 Selection of Riverbed Protection.

(c) Dimension of Groundsill

Dimensions of the groundsill are designed as follows (refer to Appendix 5-3).

Table 2-2.28 Dimensions of Groundsill

Items	Design Conditions	Required Dimensions	Designed Dimensions	Remarks
1. Groundsill	Water Head: 1.00m	Up Side slope: Vertical Dn Side Slope 1 : 0.5	Up Side slope: Vertical Dn Side Slope 1 : 0.5	・Refer to practical examples of Japan
2. Length of Dn Apron	Dam up Head :1.00m Bligh's Coefficient (gravel) C = 6	Required Length: la = 3.60m	Design Length: la = 5.00m	・To secure the apron length against overflow water ・To Secure the creep length
3. Creep Length	Water Head: 1.00m Bligh's Coeff. C = 6 Lane's Coeff. C' = 2.5	Bligh: S = 6.00m Lane: L = 2.50m	Bligh: S = 910m Lane: L = 4.77m	・Length of Dn Apron is on the safe side.
4. Thickness of Dn Apron	Water Head: 1.00m Head Loss (up to point A): Hf = 0.45m	Required thickness: ta = 0.54m	Design thickness: ta = 0.60m	・To scure the thickness against up lift pressure
5. Length of Riverbed Protection	Flood: q = 13.18m^3/s/m Dam up Head: H=1.00m	Required Length: L= 16.89m	Design Length: L = 18.00m	・6 rows×@ 3.0m
6. Riverbed Protection Block	Velocity: V = 6.59m/sec	Cast-in-place Concrete Block Crossing Type Allowable: Va = 7.5m/sec	Block Sized Design Weight: W = 8.0ton, Width 2.7m ×2.7m ×Height 1.0m	・Block is selected based on availability of local procurement

Note Dn: Downstream, Coeff: Coefficient

③ Revetment

Table 2-2.29 Selection of Revetment for River Crossing No.1

Revetment Name	Velocity of Control Discharge flood（m/sec）	Height of Revetment（m）	Slope Gradient	Type of Revetment	Allowable Maximum Velocity（m/sec）
Upstream Revetment	5.40 × 1.2 = 6.48	3.00	1 : 0.5	Wet Masonry（Depth about 50cm）	7.0
Revetment at Groundsill	5.40 × 1.5 = 8.10	1.50	1 : 0.5	Leaning Type Concrete Retaining Wall	9.0
Revetment at Downstream Apron	5.40 × 1.5 = 8.10	2.50	1 : 0.5	Leaning Type Concrete Retaining Wall	9.0
Downstream Revetment	5.40 × 1.2 = 6.48	3.00	1 : 0.5	Wet Masonry（Depth about 50cm）	7.0

Note 1. Velocities at the up and downstream revetments at the time of flow at the control discharge are estimated with 20% increment taking into account of influence of the drop of groundsill.

2. Velocities at the groundsill and the downstream apron at the time of flow at the control discharge are estimated with 50% increment taking into account of direct influence of the drop of groundsill.
3. Coverage of reinforcement steel bar of the groundsill and the revetment of the downstream apron, ie leaning type retaining wall is increased to 6.5 cm by adding 1.5 cm to the normal coverage of 5.0 cm because their velocity exceeds the allowable maximum velocity of 6.0m/sec.

Revetment type is selected as follows based on the Table 2-2.14 Applicable Condition for revetment, in the section 2-2-2-5 Selection of Revetment.

(2) Structure No.5: River Terrace at Right Bank, Tributary Crossing and Approach Bank to Upstream Retaining Wall（Sta.0 + 584.16 (IP.19) ～ Sta.0 + 742.38 (IP.22) ）

① Plan of Alignment

Rerouting and aqueduct for tributary crossing at right bank are selected as the improvement method of this section through the comparative study in the section 2-2-2-8-2. At the upper part of the existing pipe exposed section (IP.19), rerouting pipeline is branched to pass the right bank near mountain foot, then crossing the tributary by the short span pipe aqueduct and finally connecting again with the existing raw water main at the appropriate point in the downstream. Diameter of the rerouting pipe is planned as the same size of 250 mm as the existing pipe. Alignment of the proposed pipeline is basically planned at the distance of 12m away from the existing raw water main toward the mountain side of right bank taking into account of the configuration of circumference and present appearance of the old pipeline (refer the DWG 11,12 and 13, in the section 2-2-3 Basic Design Drawings).

② Plan of Tributary Crossing

An aqueduct is planned for the tributary crossing in consideration that excavation to bury the pipeline under riverbed is difficult and costly because of congestion of numerous boulders at the riverbed and further old aqueduct is still remaining with a slight damage caused by a falling rock. Accordingly, the aqueduct is designed with the pipe height with additional freeboard of more than 1.0m above the design flood water level of the tributary which is higher than the old aqueduct level and with the shortest span consisting with the width of the flow path of the tributary. The simple beam type (one side is fixed and another side is movable) is applied to the aqueduct because of short span of only 10.4m.

③ Plan of Revetment and Riverbed Protection

A flow path is planned to protect the tributary at the section where aqueduct crosses. The flow path is composed of a wet masonry revetment and riverbed protection by wet stone pitching (bed width: 6m, wall height: 1.5m, slope gradient 1 : 0.5, bed slope: 1/13). Protection range covered by the flow path is each 10m in length for up and downstream of the aqueduct.

In addition to the above, the wet stone masonry revetment is arranged at the upstream part of Bemos river right bank for 55m and at the downstream part for 30m in length. The thickness of 50cm is selected for the wet masonry revetment which is given in the Table 2-2.14 at the velocity of control discharge of 6.64m/sec.

④ Operation and Maintenance Facility

For operation and maintenance, an air valve is planned on the aqueduct and a wash-out and an isolating valve are planned at the upstream of the aqueduct.

(3) Structure No.6: Existing Upstream Concrete Retaining Wall (Sta.0 + 787 ～ Sta.0 + 876）

① Plan of Alignment

The right bank river terrace has been scoured seriously by the floods occurred in 2004 and 2005 which was enhanced by water route drifting to the right bank in this river reach and then the raw water main has been exposed. For the countermeasure, DNSAS has constructed the gravity type concrete retaining wall as a emergency protection measure against further river terrace scouring by a flood. The retaining wall is still in sound condition without any scouring at its foundation. However, many rocks falling are expected from the slope of right bank in this section and the some damages by the rock fall are observed on the pipe surface of the raw water main. Since no defect of the raw water main to cause malfunction is reported, it is planned to utilize the existing pipe with bury again by soil coverage.

For this purpose, the existing retaining wall crest will be raised up if necessary and reused. In addition, the retaining wall will be submerged in the flood and the velocity at the top of the retaining wall in the flood is expected as fast as about 3.4m/sec so that the flood channel at the top of the retaining wall is planned to be covered by a gabion for protection of the raw water main from further scouring and exposure by the flood.

Meanwhile, the raw water main between Sta.0+850 and Sta.0+880 (Air valve AR80-02) is raised up more than 2.0m higher than the top of the retaining wall. The retaining wall will lose its stability by the earth pressure if the pipe is covered by the soil in this section, therefore, the raw water main will be rerouted at the lower alignment and covered by the gabion and filled with sand and gravel (refer to the DWG 14, in the section 2-2-3).

② Operation and Maintenance Facility

Air valve No.2 (AR80-02) shall be shifted by 15m toward downstream because the raw water main is rerouted and reconnected to the existing one at the location where the retaining wall is not required to support the buried pipe. The existing air valve will be reused for the shifted one.

In addition to the above, a wash-out will be newly installed at the immediate upstream of the standing pipe due to concavity profile of the pipeline, and an isolating valve will be also installed at the immediate upstream of the conjunction point with the existing raw water main to facilitate the wash-out operation.

(4) Structure No.7: River Terrace at Right Bank (Sta.0 + 876 ～ Sta.0 + 947)

① Plan of Alignment

The raw water main route is aligned on the right bank terrace with the length of about 250 m and 5～6 m height for the section between the end of upstream revetment and the river crossing No.2. The slope of right bank terrace is rather steep and no new scoured trace is found. But there is a possibility of scouring the terrace if the river course changes, which is found out in the site survey that the river course may be changed easily in a flood tome due to the effect of water colliding to the fallen rock or drift stone. As the result of the site survey, the revetment is planned at the upstream of the terrace for around 100m in length and the existing raw water main is utilized as it is (refer to the DWG 14, in the section 2-2-3).

② Plan of Revetment

The wet masonry revetment at the low water channel is planned with 1.6m in height, slope 1: 0.5 and 0.5m in depth based on the velocity of 6.64m/sec at the control discharge obtained by the hydraulic calculation which is an index to select the type of revetment in the low water channel. Furthermore, the flood channel is protected by the gabion because the velocity there is estimated at 3.39m/sec at the design flood.

(5) Structure No.8: River Crossing No.2 (Sta.1 + 142 ～ Sta.1 + 220)

① Existing Raw Water Main and Protection Concrete

The existing raw water main and its concrete protection placed above the pipeline are still functioning soundly though the surface of the concrete protection has been abraded away and damaged by the drift stone or etc. during the flood, so, it will be used as it is. In order to secure the safety of the existing pipe in future, approximate 2.0m of earth coverage is required for the pipe. Since the groundsill with high drop of approximately 2.5m between up and downstream is required in the case of earth coverage, the existing pipe is secured with its safety by the protection of a concrete apron with 0.5m in thickness instead of earth coverage of 2.0m.

② Groundsill for Pipe Protection

(a) Groundsill

The downstream riverbed at the existing river crossing has been scoured by the depth of about 0.6m. The drop of the groundsill is estimated at 1.1m taking into account the thickness of 0.5m of the concrete apron to protect the existing raw water main. Upstream slope of the groundsill is designed vertical and downstream one is 1: 0.5 referring the experimental sample of Japan to secure the stability of the groundsill under the circumstance of the flood with action of the earth pressure up to crest of the groundsill (EL 170.20m).

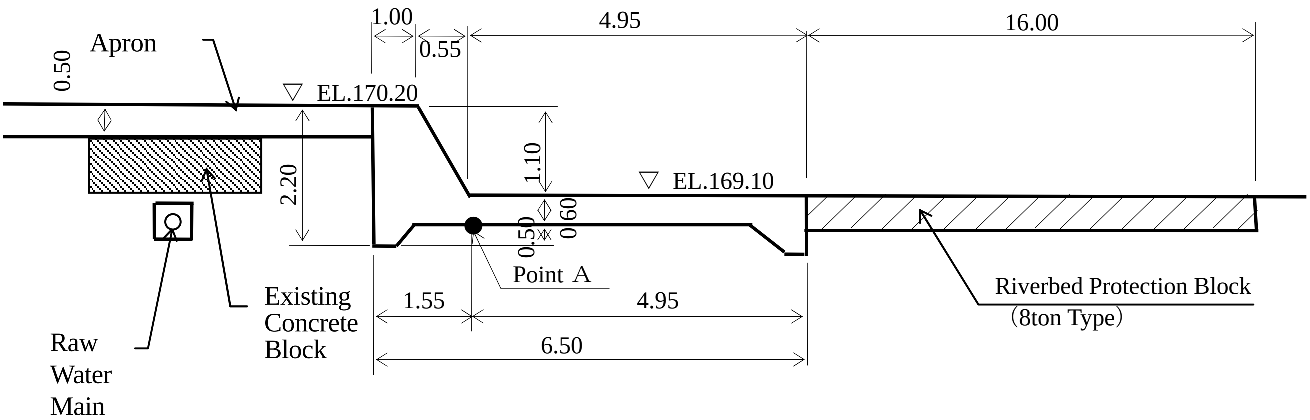


Fig. 2-2.15 Typical Section of Groundsill

(b) Downstream Apron

The downstream apron is provided to protect riverbed from scouring by falling water overflowing the groundsill. Dimension of the downstream apron is designed as follows based on the design standard of head works, Ministry of Agriculture, Forestry and Fisheries, Japan (refer to Appendix 5-4).

1) Length of Apron

The length of apron is designed in accordance with the conditions of drop height of groundsill and foundation ground.

2) Creep Length

In order to prevent a piping of foundation, it is necessary to secure the enough creep length along the perimeter of groundsill and backside of a revetment. The creep length to be secured is selected with longer one between two figures calculated by the Bligh formula and the Lane formula.

3) Thickness of Downstream Apron

The thickness of the downstream apron is designed by the equation relevant to the balance of uplift pressure. The maximum uplift pressure will be given at the point A indicated in the above figure which will give the maximum thickness of the downstream apron.

4) Downstream Riverbed Protection

a) Length of Riverbed Protection

Drop water energy after overflowing the groundsill is dissipated through the downstream apron and riverbed protection. Required length of the downstream riverbed protection is given by the experimental Bligh formula.

b) Type and Weight of Downstream Riverbed Protection

Type and the weight of the downstream riverbed protection is selected based on the Table 2-2.18

Applicable Condition, in the section 2-2-2-6 Selection of Riverbed Protection.

(C) Dimension of Groundsill

Dimensions of the groundsill are designed as follows (refer to Appendix 5-4).

Table 2-2.30 Dimensions of Groundsill

Items	Design Conditions	Required Dimension	Designed Dimension	Remarks
1. Groundsill	Water Head: 1.10m	Up Side slope: Vertical Dn Side Slope 1 : 0.5	Up Side slope: Vertical Dn Side Slope 1 : 0.5	・Refer to practical examples of Japan
2. Length of Dn Apron	Dam up Head :1.10m Bligh's Coefficient (gravel) C = 6	Required Length: la = 3.78m	Design Length: la = 4.95m	・To secure the apron length against overflow water ・To secure the creep length
3. Creep Length	Water Head: 1.10m Bligh's Coeff C = 6 Lane's Coeff C' = 2.5	Bligh: S = 6.00m Lane: L = 2.75m	Bligh: S = 920m Lane: L = 4.77m	・Length of Dn Apron is on the safe side.
4. Thickness of Dn Apron	Water Head: 1.10m Head Loss (up to point A): Hf = 0.51m	Required thickness: ta = 0.58m	Design thickness: ta = 0.60m	・To secure the thickness against up lift pressure
5. Length of Riverbed Protection	Flood: q = $10.75m^3/s/m$ Dam up Head: H=1.10m	Required Length: L= 15.79m	Design Length: L = 16.00m	・6 rows ×@ 3.0m
6. Riverbed Protection Block	Velocity: V = 5.12m/sec	Cast-in-place Concrete Block Crossing Type Allowable: Va = 7.5m/sec	Block Sized Design Weight: W = 3.0ton, Width 1.7m ×1.7m× Height 1.0m	・Block is selected based on availability of local procurement

Note Dn: Downstream, Coeff: Coefficient

③ Revetment

Revetment type is selected as follows based on the Table 2-2.14 Applicable Condition for revetment, in the section 2-2-2-5-2 Selection of Revetment.

Table 2-2.31 Selection of Revetment for River Crossing No.2

Revetment Name	Velocity of Control Discharge flood (m/sec)	Height of Revetment (m)	Slope Gradient	Type of Revetment	Allowable Maximum Velocity (m/sec)
Upstream Revetment	3.44 × 1.2 = 4.12	3.20	1 : 0.5	Wet Masonry (Depth about 50cm)	7.0
Revetment at Groundsill	3.44 × 1.5 = 5.16	1.70	1 : 0.5	Leaning Type Concrete Retaining Wall	6.0
Revetment at Downstream Apron	4.24 × 1.5 = 6.36	2.80	1 : 0.5	Leaning Type Concrete Retaining Wall	9.0
Downstream Revetment	4.24 × 1.2 = 5.09	3.10	1 : 0.5	Wet Masonry (Depth about 50cm)	7.0

Note 1. Velocities at the up and downstream revetments at the time of flow at the control discharge are

estimated with 20% increment taking into account of influence of the drop of groundsill.

2. Velocities at the groundsill and the downstream apron at the time of flow at the control discharge are estimated with 50% increment taking into account of direct influence of the drop of groundsill.
3. Coverage of reinforcement steel bar of the groundsill and the revetment of the downstream apron, ie leaning type retaining wall is increased to 6.5 cm by adding 1.5 cm to the normal coverage of 5.0 cm because their velocity exceeds the allowable maximum velocity of 6.0m/sec.

(6) Structure No.10-1: Downstream Concrete Retaining Wall（Sta.1 + 420 ～ Sta.1 + 530）

The Bemos river makes turn to the left bank at the downstream of the river crossing No.2 and then forms a water colliding front of river flow at the concrete retaining wall which is located at the distance of 100m downstream from the Break Pressure Tank. As-built drawing indicated that these part has previously been protected by the gabion, however, it has been washed away by the flood occurred in the year 2004. Although the raw water main has been laid underground previously, the pipe foundation also washed away by the flood and the pipe has been exposed. Then, DNSAS has rehabilitated the raw water main as the exposed pipeline with supporting by the concrete column. But, three supports out of eight have been washed away at their sub-structure by the flood occurred in the year 2005.

As the water route of Bemos river hits the pipeline foundation and erode it directly, DNSAS constructed the concrete gravity type retaining wall as a revetment against water colliding. The pipeline is planned to be buried to protect from falling rock because the pipe has no damage as it looks in this section but having high risk of damage by falling rocks from river bank slope in consideration of dispersed fallen rocks around the pipe.

For this purpose, the existing retaining wall will be utilized effectively by heightening its crest. In addition, the strengthening of the footing and riverbed protection works are planned as a measure against the falling down of the retaining wall due to scouring of foundation (refer to DWG 17, in the section 2-2-3).

① Planning for Revetment and Riverbed Protection

Scoured section at the foundation of the retaining wall will be strengthened by concrete filling. Due to high velocity of 5.34m/sec in the design flood, cast-in-place concrete blocks (3ton) will be placed additionally. The range of block installation is limited to the length of the existing retaining wall. Meanwhile, the raw water main will be covered by embankment to protect from falling rocks. Since the coverage is required for 0.6m in thickness as the minimum, heightening the top of the retaining wall is partially planned as required. As high water level of the design flood is estimated at lower than the top elevation of the retaining wall, flood channel will be filled by the mixture of sand and gravel available in the site.

② **Operation and Maintenance Facility**

As the pipeline has a shape of concavity at the downstream of the existing retaining wall (Sta.1+500) and it is found out that DNSAS has tried to make wash out operation by means of pipe cutting, a wash-out and an isolating valve are planned to be newly installed. Further, the section around IP.36 (Sta. 1 + 530) has also a shape of concavity causing high possibility of air accumulation and therefore, the air valve will be newly installed.

(7) Structure No.10-2: 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 (refer to DWG 18, in the section 2-2-3).

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.

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.

(8) Structure No. 10-3: Bemos Left Bank Terrace (Section of pipe hanging in the air)
（Sta.2 + 094 ～ Sta.2 + 200）

In this section, the flood scoured the river bank terrace where the raw water main has been buried and then the raw water main is exposed and hanging in the air for about 100m reach. Up and downstream reaches also have a possibility to be scoured easily and damaged by the next flood. In accordance with the result of alternative study between the pipe protection method by the revetment and the pipe laying method under the riverbed in the section 2-2-2-8-2, the latter one is selected (refer to DWG 19, in the section 2-2-3).

① **Plan of Alignment**

The section for 200m in length which includes exposed pipeline section and its up and downstream reach where most likely to suffer from scouring will be shifted to the underground of the riverbed. As it is preferable to relocate to the near place of the existing pipe alignment from the view point of economic and riverbed stability, the new pipeline will be aligned in parallel with the existing raw water main at the distance of about 5m toward riverbed in view of easier construction.

② Protection of Pipe and Riverbed Protection

The same pipe laying method as the river crossing is applied to this section because the pipe is aligned under the riverbed. The pipe is packed with the concrete encasement and further covered by the concrete block for protection. Furthermore, as the lowest riverbed would be drifted by the future flood, the surface elevation of the riverbed protection is set at the elevation of the riverbed. A plain concrete is applied for the pipe encasement and encasement thickness is set at 0.35m in conformity with the Standard of Sabo Works of Japan.

A cast-in-place concrete block (3ton) is arranged for riverbed protection in accordance with the velocity of 5.63m/sec at the design flood. In addition, width of the riverbed protection is planned at about 6.0m with arrangement of three rows of concrete blocks based on the example of Japan of which width of 10m is generally required in case of the protection of river facilities.

③ Operation and Maintenance Facility

The conjunction point with the existing pipe at the downstream end of rerouting pipe has a shape of convexity, so that an air valve is installed at the highest point. Meanwhile, a new wash-out is installed at the downstream end of buried pipeline under riverbed where is the lowest point and shows a concave shape. Furthermore, an isolating valve is newly installed at the conjunction point with the existing pipe just downstream of the air valve to facilitate the wash-out operation.

(9) 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 (refer to the DWG 20 and 21, in the section 2-2-3).

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.

(10) Structure No.17: 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.

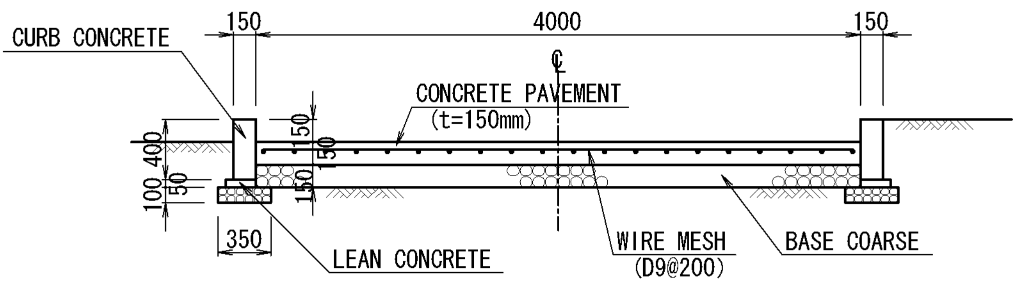


Fig. 2-2.16 Typical Section of Road

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 2-2.29. 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.

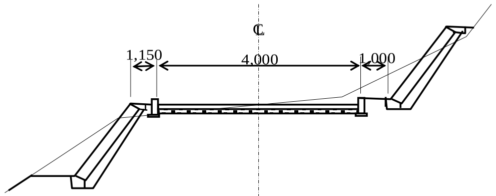
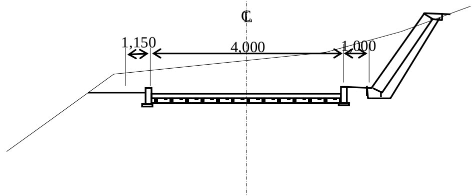
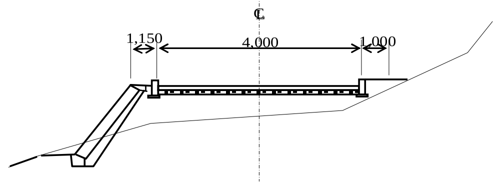
2) Plan B: traveling performance for vehicle becomes better due to the maximum longitudinal slope improvement to 19.5% which is the same with Plan C.

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 2-2.32 Comparison of the Longitudinal Sloping Method for Access Road

I t e m s	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 $217.3m^2$	・Earth Retaining Works : Length 38.5m Wet Masonry $122.8m^2$ ・Road side structure : Length 56.5m Wet Masonry $176.7m^2$	・Earth Retaining Works : Length 38.5m Wet Masonry $90.5m^2$ ・Road side structure : Length 76.0m Wet Masonry $235.4m^2$
	・ Total : Length 66.0m Wet Masonry $217.3m^2$ Small scale incidental facility is required. Best（1.00）	・ Total : Length 95.0m Wet Masonry $299.5m^2$ Rather large scaled incidental facility is required. Better（1.38）	・ 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 (10^3Yen) ・Cap Conc. : 66.0×4,200 = 277.2 (10^3Yen) ・Base Conc. : 66.0×6,100 = 402.6 (10^3Yen)	・Wet Masonry : 299.5×9,100 =2,725.5 (10^3Yen) ・Cap Conc. : 95.0×4,200 = 399.0 (10^3Yen) ・Base Conc. : 95.0×6,100 = 579.5 (10^3Yen)	・Wet Masonry : 325.8×9,100 =2,964.8 (10^3Yen) ・Cap Conc. : 114.5×4,200 = 480.9 (10^3Yen) ・Base Conc. : 114.5×6,100 = 698.5 (10^3Yen)
	・Total : 2,657.2 (10^3Yen) Best（1.00）	・Total : 3,704.0 (10^3Yen) Better（1.39）	・Total : 4,144.2 (10^3Yen) 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.

2-2-2-8-4 Operation and Maintenance Facilities

Concerning the O & M facilities such as Air Valve, Isolating Valve and Wash-out, utilization plan of the existing facility or new construction have been planned as shown in the following table in accordance with the policy studied in the section 2-2-1-2-7. The existing Pressure Reduce Tank, which bears important function to regulate water pressure in the raw water main, will be utilized as it is because of the proper working condition at present. The location of each facility shall be referred to the DWG 1 and DWG 2: Profile of the Bemos Raw Water Main in the section 2-2-3 Basic Design Drawing. Additionally, facility design shall be referred to the DWG 23: Standard Detail of Isolation Valve, Wash-Out & Air Valve Chambers.

Table 2-2.33 Operation and Maintenance Facility Plan

Facility	Location Sta.	Valve (nos.)	Chamber (nos.)	Cover (nos.)	Discharge Pipe (mm) x (m)	Structure No. or Location Name	Reuse or New const.
Existing Air Valve							
AR80-01	0+545	-	1			No.4	Use
AR80-02 (Ex.)	0+879	Detach	Removal	Removal		No.6	Transfer
AR80-02 (New)	0+895	Diversion	1	1		No.6	
AR80-03	1+258					No.8	Use
AR08-04	1+975			1		No.10-3	Use
AR80-05 (Ex.)	2+110	Detach				No.10-3	Transfer
AR80-05 (New)	2+193	Diversion	1	1		No.10-3	
AR08-07	3+845					River Crossing No. 3	Use
AR08-No Num.	IP.67(4+136)						Use
AR80-09(16PN)	IP.97(7+053)		1 (Mid. Load)			No.17	Use
Additionally Proposed Air Valve							
ARAD80-01	0+674	1				No. 5 (Aqueduct)	New Const.
ARAD80-02	1+525	1	1	1		No.10-1	New Const.
ARAD80-03	2+500	1	1	1		No.11	New Const.
Existing Isolation Valve							
IR250-01	0+009	Removal	Removal			No.1	Removal
IR250-02	1+355					No.9	Use
IR300-01	1+361	Replace	(Due to leakage)			No.9	Replace
IR300-02	2+705		1	1		No.12	Use
IR300-03	3+500						Use
IR300-04	3+907					River Crossing No. 3	Use
IR300-05	4+925		1	1			Use
Bemos WTP φ２００	6+826		2	2		Branch to Bemos W.T.P	Use
IR300-08(16PN)	7+062						Use
Additionally Proposed Isolating Valve							
IRAD250-01	0+657	1	1	1		No. 5 (Aqueduct)	New Const.
IRAD250-02	0+900	1	1	1		No.6	New Const.
IRAD300-01	1+502	1	1	1		No.10-1	New Const.
IRAD300-02	2+195	1	1	1		No.10-3	New Const.
Existing Wash-out							
WR80-01	0+008	Removal	Removal			No.1	Removal
WR80-02	IP.30(1+219)		1	1	φ80x45m	No.8	Use
WR80-03	3+835					River Crossing No.3	Use
WR80-04	IP.96(6+995)					No.17	Halt
Additinally Proposed Wash-out							
WRAD200-01	0+500	1	1	1	φ200 x 30m	River Crossing No.1 (No.4)	New Const.
WRAD200-02	0+656	1	1	1	φ200 x 16m	No.5	New Const.
WRAD200-03	0+889	1	1	1	φ200 x 8m	No.6	New Const.
WRAD200-04	1+509	1	1	1	φ200 x 5m	No.10-1	New Const.
WRAD200-05	1+950	1	1	1	φ200 x 5m	No.10-2	New Const.
WRAD200-06	2+187	1	1	1	φ200 x 5m	No.10-3	New Const.
WRAD200-07	2+425	1	1	1	φ200 x 8m	No.11	New Const.
WRAD200-08 (16NP)	6+995	1	1	1	φ200 x 8m	No.17	New Const.

2-2-2-9 Improvement Plan of the Lower Service Reservoir and Valve Chamber in Bemos Water Treatment Plant

2-2-2-9-1 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.2-2.17 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 2-2.34 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 2-2.34 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	424 m^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

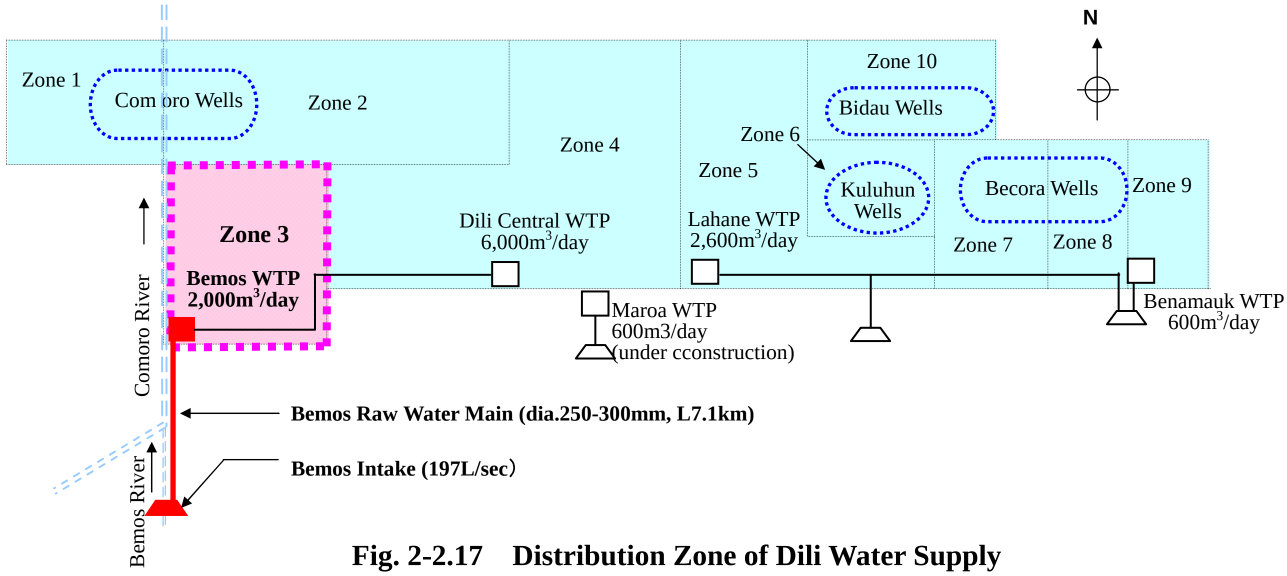


Fig. 2-2.17 Distribution Zone of Dili Water Supply

(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 2-2.35 (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 2-2.35 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

2-2-2-9-2 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 Table2-2.36. 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. Table2-2.37 shows the evaluation results on the renovation of the Lower Service Reservoir based on Guideline on Renovation of Waterworks.

Table 2-2.36 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 2-2.37 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).

2-2-2-9-3 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. 2-2-18) and the south side (plant side: B – B line on Fig. 2-2-18) 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

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. 85.45m + 0.05m + 0.35m
  = EL. 85.85m
- Low Water Level : = Floor level of planned reservoir + allowance 0.15m *
  = EL. 85.85m + 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. 90.025m － 0.5m － 0.325m
  = EL. 89.20m
- High Water Level : = Top of the upper slab － top plate － allowance 0.3m *
  = EL. 89.20m － 0.20m － 0.30m
  = H.W.L. 88.70m

* 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
- Inner Height： = (top of the upper slab － top plate) － Floor level
  = （EL. 89.20m － 0.20m） － EL. 85.85m
  = 3.15m
- Effective Depth： = High Water Level － Low Water Level
  = H.W.L. 88.70m － L.W.L. 86.00m
  = 2.70m
- Effective Width： = （Effective Capacity + diverting wall） ÷（Inner length × Effective Depth）
  = （$500m^3$ ＋ 5.20m×0.25m×2.70m×6plates） ÷（12.55m×2.70m）
  = 15.38m ≒ 15.60m
  = 2×7.80m
- Inner Width： = Effective Width + dividing wall
  = 15.60m + 0.25m
  = 15.85m

Table 2-2.38 Planned data of the Lower Service Reservoir

Dimension	Water Level	Foundation	Infrastructure
W: 15.85m L: 12.55m H: 3.15m Rectangular tank	H.W.L.: +88.7m L.W.L: +86.0m Effective Depth：2.70m Effective Capacity：500 ㎥	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.

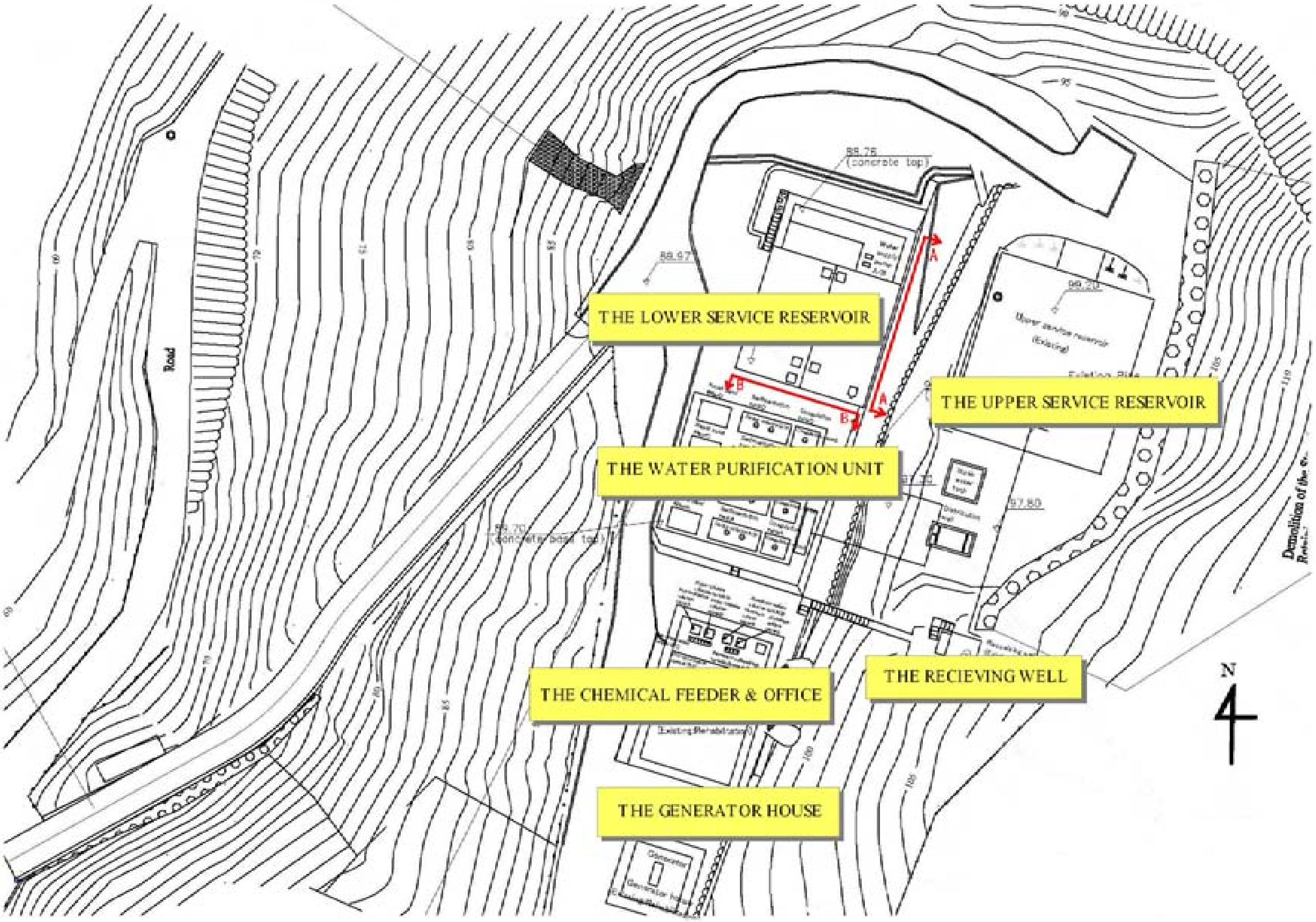


Fig. 2-2.18   Layout of Bemos Water Treatment Plant

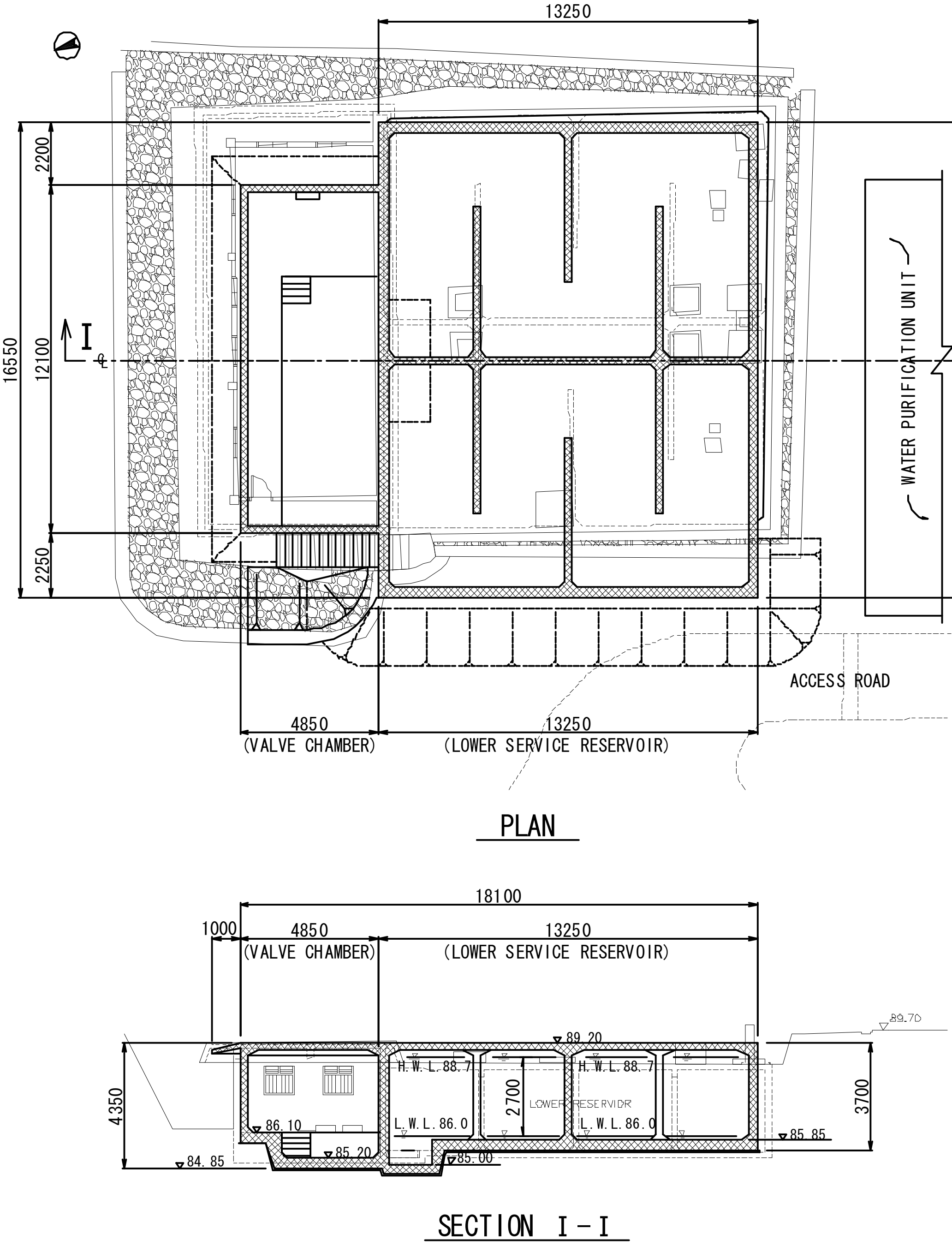


Fig. 2-2.19 Basic Plan of the Lower Service Reservoir

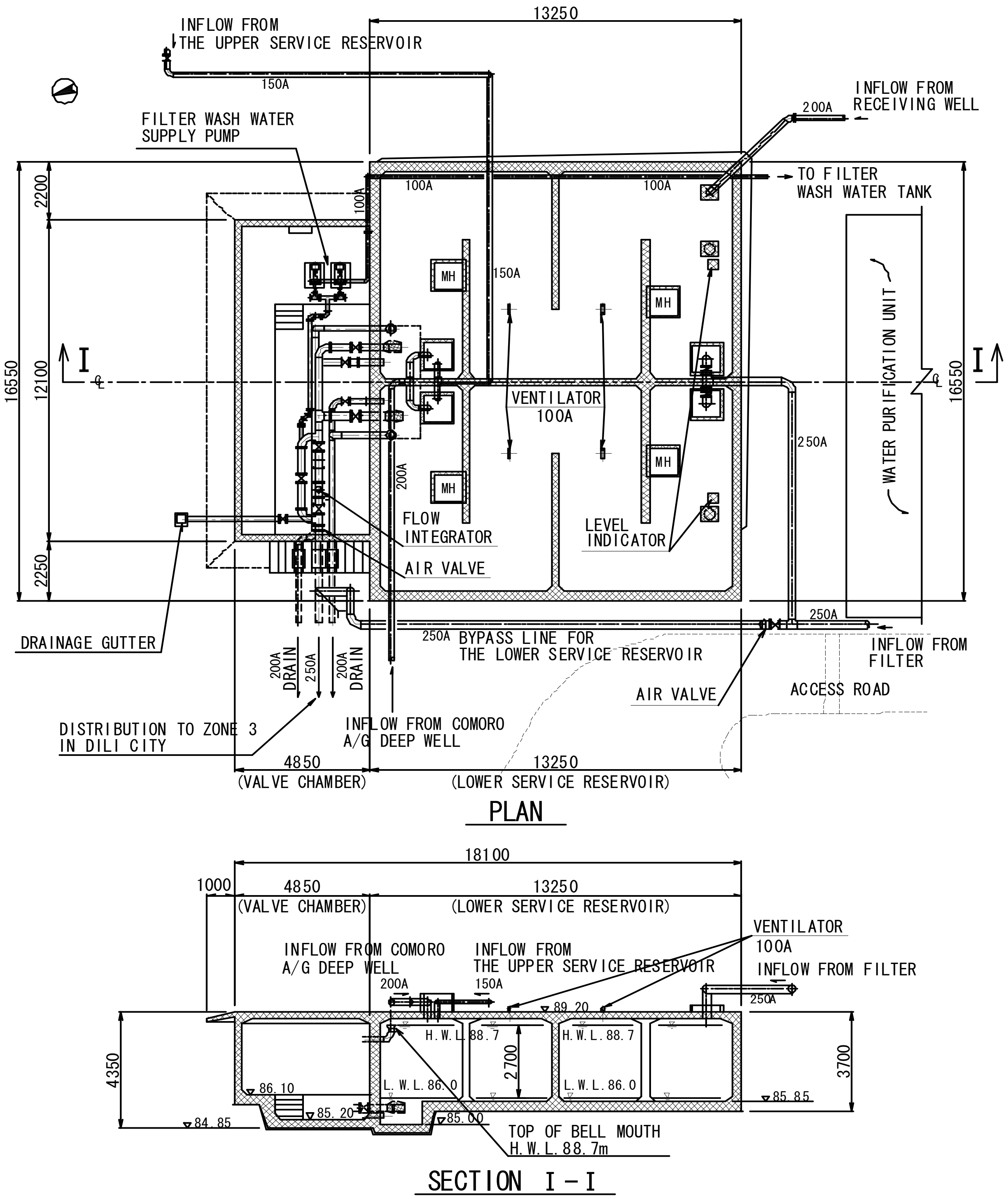


Fig. 2-2.20 Pipe Arrangement of Lower Service Reservoir

④ Materials / Construction Method

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

Table 2-2.39 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

2-2-2-9-4 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 2-2.40 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.2-2.21 for Ⓐ−Ⓕ,

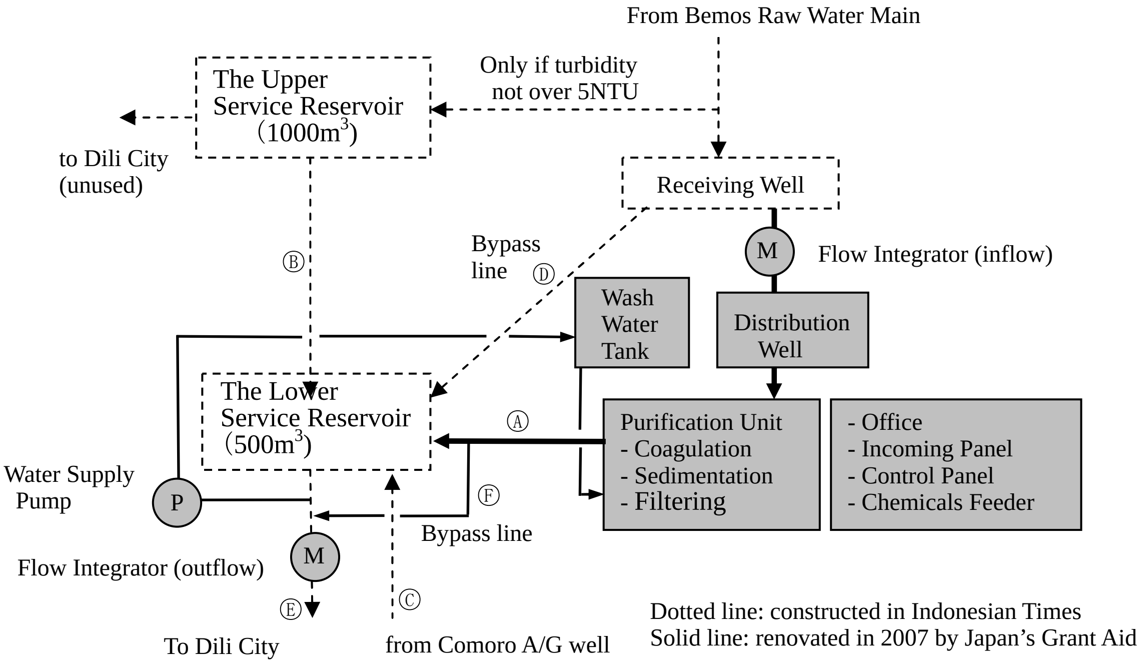


Fig. 2-2.21 Piping System in Bemos Water Treatment Plant

(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 2-2.41 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 Ⓕ

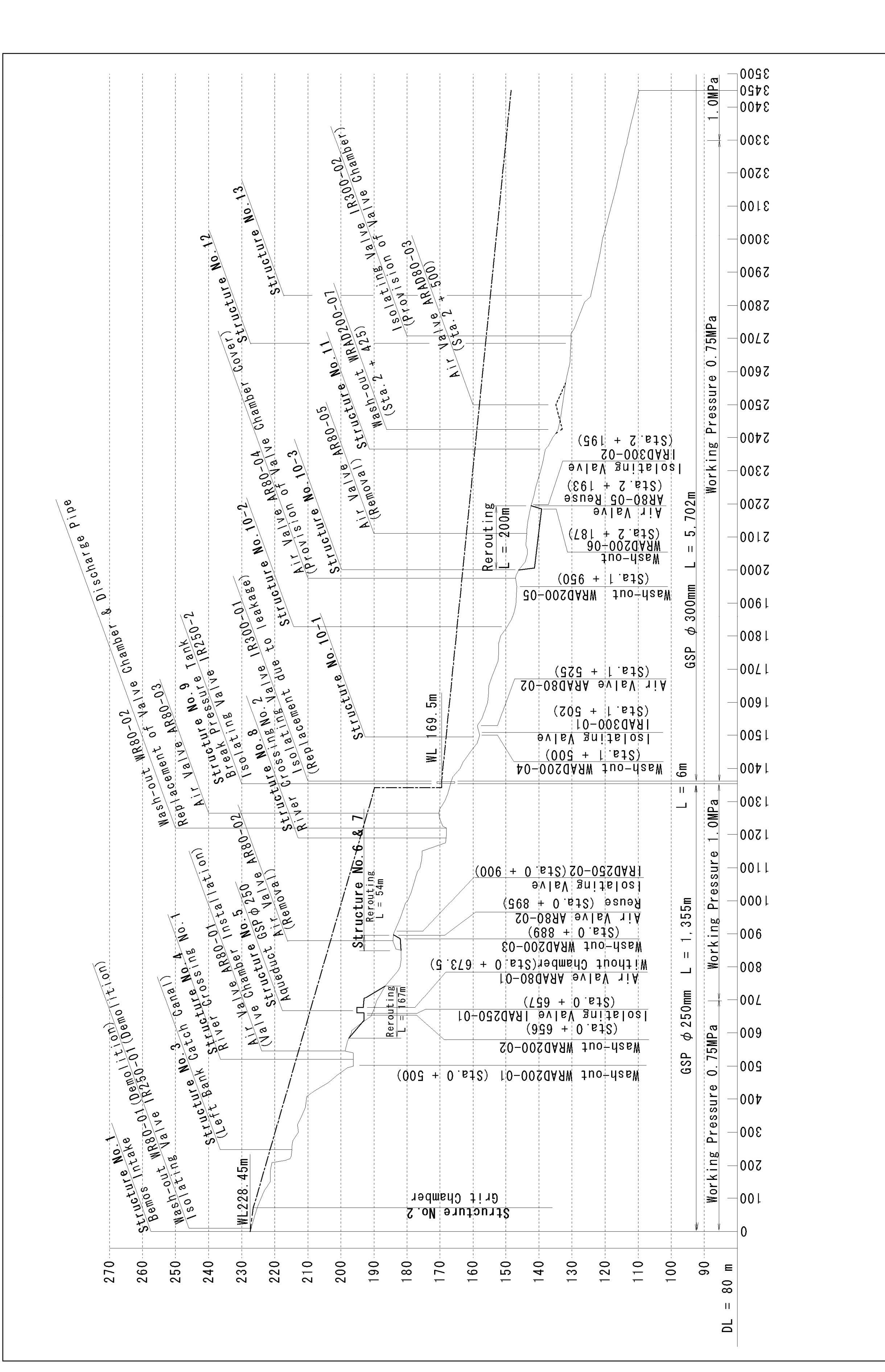
* Refer to Fig.2-2.21 for Ⓐ−Ⓕ,

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.

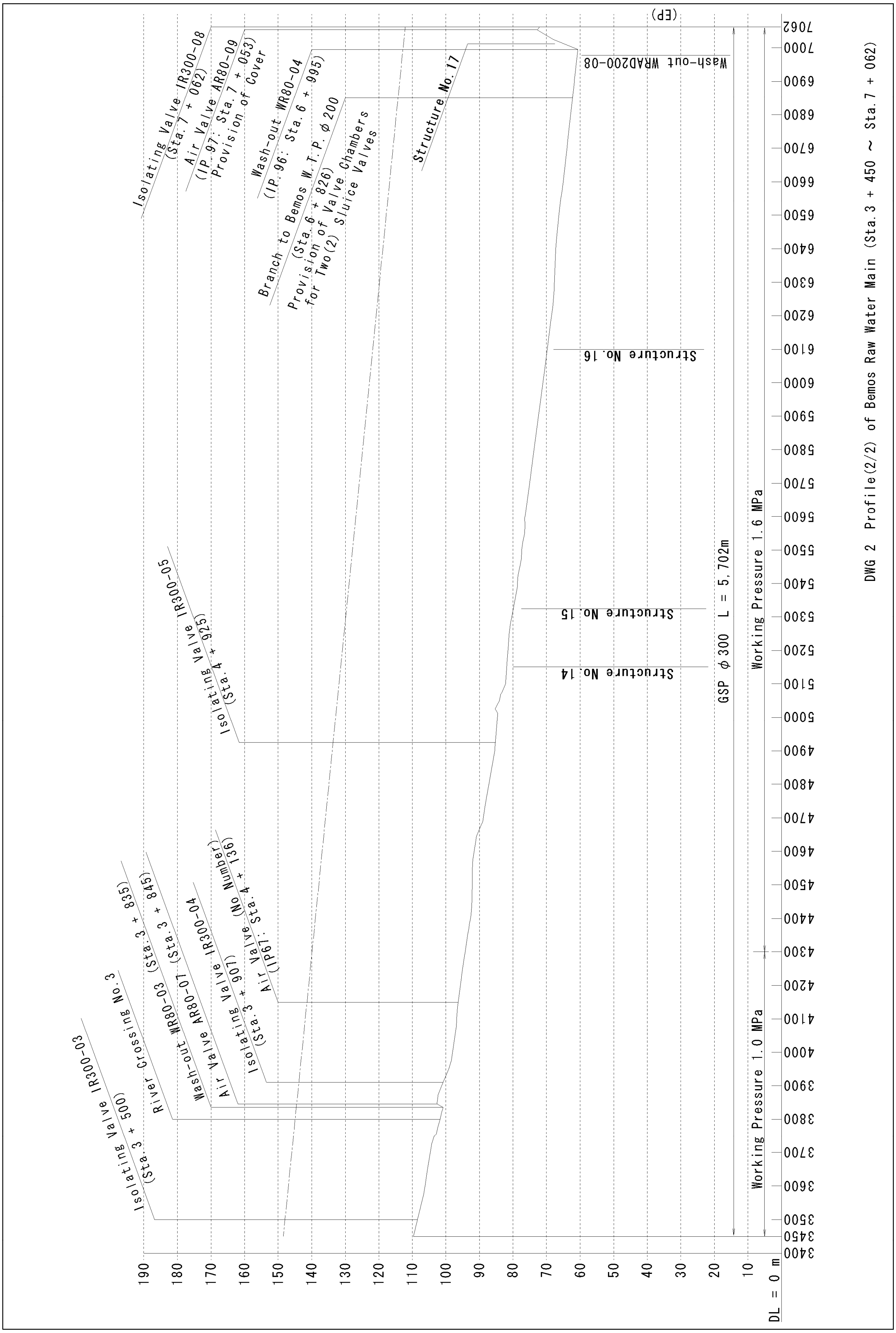
2-2-3 Basic Design Drawings

Table 2-2.42 List of Drawings

Drawing No.	Drawing Title
DWG 1	Profile (1/2) of Bemos Raw Water Main (Sta.0 ~ Sta.3 + 450)
DWG 2	Profile (2/2) of Bemos Raw Water Main (Sta.3 + 450 ~ Sta.7 + 062)
DWG 3	Structure No.1 : Bemos Intake General Plan
DWG 4	Structure No.1 : Bemos Intake Elevation & Typical Section of Intake Weir
DWG 5	Structure No.1 : Bemos Intake Sections
DWG 6	Structure No.1 : Bemos Intake Plan & Profile of Intake & Connecting Canal
DWG 7	Structure No.2 : Grit Chamber Plan, Profile & Sections
DWG 8	Structure No.2 : Grit Chamber Sections
DWG 9	Structure No.4 : River Crossing No.1 General Plan
DWG 10	Structure No.4 : River Crossing No.1 Profile & Sections
DWG 11	Structure No.5 (Rerouting & Aqueduct for Tributary Crossing) Plan and Profile
DWG 12	Structure No.5 (Rerouting & Aqueduct for Tributary Crossing) Cross Section of Bemos River & Profile of Tributary
DWG 13	Structure No.5 (Rerouting & Aqueduct for Tributary Crossing) Plan & Profile
DWG 14	Structure No.6 & No.7 (Exposed Pipeline and Existing Retaining Wall & River Terrace) Plan, Profile & Sections
DWG 15	Structure No.8 : River Crossing No.2 General Plan
DWG 16	Structure No.8 : River Crossing No.2 Profile & sections
DWG 17	Structure No. 10-1 (Exposed Pipeline & Existing Retaining Wall) Plan, Profile & Section
DWG 18	Structure No. 10-2 (Improvement of Exposed Pipeline) Plan, Profile & Section
DWG 19	Structure No. 10-3 (Improvement of Exposed Pipeline by Rerouting under River Bed) Plan, Profile & Section
DWG 20	Structure No.11 (Improvement of Exposed Pipeline) Plan, Profile
DWG 21	Structure No.11 (Improvement of Exposed Pipeline) Sections
DWG 22	Structure No.17 Pipe Protection & Concrete Pavement of Access Road
DWG 23	Standard Detail of Isolating Valve, Wash-Out & Air Valve Chambers
DWG 24	Typical Sections of Wet Masonry
DWG 25	Layout of Lower Service Reservoir of Bemos WTP
DWG 26	Section of Lower Service Reservoir of Bemos WTP



DWG 1 Profile(1/2) of Bemos Raw Water Main (Sta.0~Sta.3 + 450)



DWG 2 Profile(2/2) of Bemos Raw Water Main (Sta.3 + 450 ~ Sta.7 + 062)
Isolating Valve IR300-03 (Sta.3 + 500)
River Crossing No.3 (Sta.3 + 835)
Wash-out WR80-03 (Sta.3 + 845)
Air Valve AR80-07
Isolating Valve IR300-04 (Sta.3 + 907)
Air Valve (No Number) (IP67: Sta.4 + 136)
Isolating Valve IR300-05 (Sta.4 + 925)
Structure No.14
Structure No.15
Structure No.16
Branch to Bemos W.T.P. φ200 (Sta.6 + 826)
Provision of Valve Chambers for Two(2) Sluice Valves
Structure No.17
Wash-out WR80-04 (IP.96: Sta.6 + 995)
Wash-out WRAD200-08
Air Valve AR80-09 (IP.97: Sta.7 + 053)
Provision of Cover
Isolating Valve IR300-08 (Sta.7 + 062)
(EP)
GSP φ300 L = 5,702m
Working Pressure 1.0 MPa
Working Pressure 1.6 MPa
DL = 0 m
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
3400
3450
3500
3600
3700
3800
3900
4000
4100
4200
4300
4400
4500
4600
4700
4800
4900
5000
5100
5200
5300
5400
5500
5600
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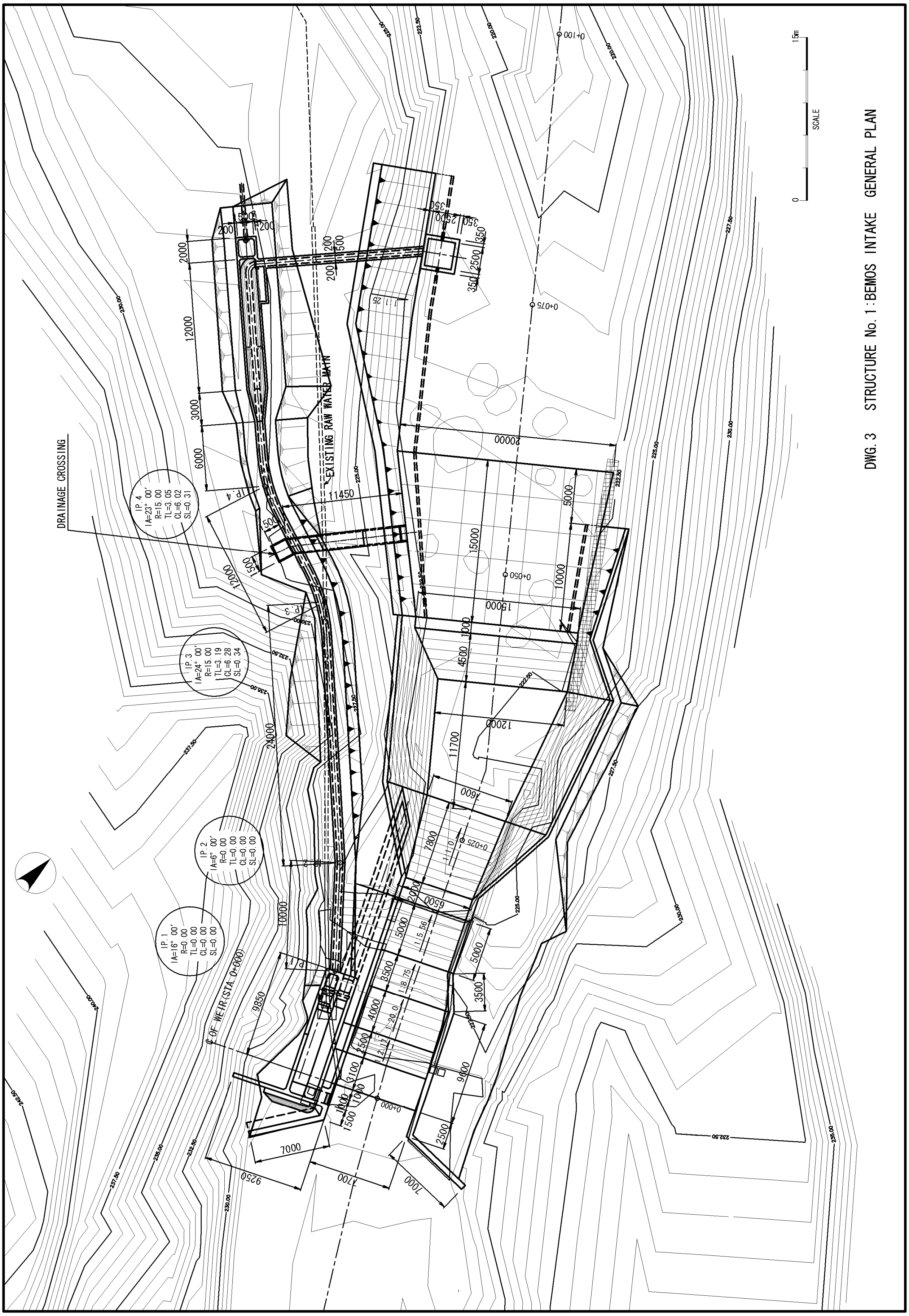
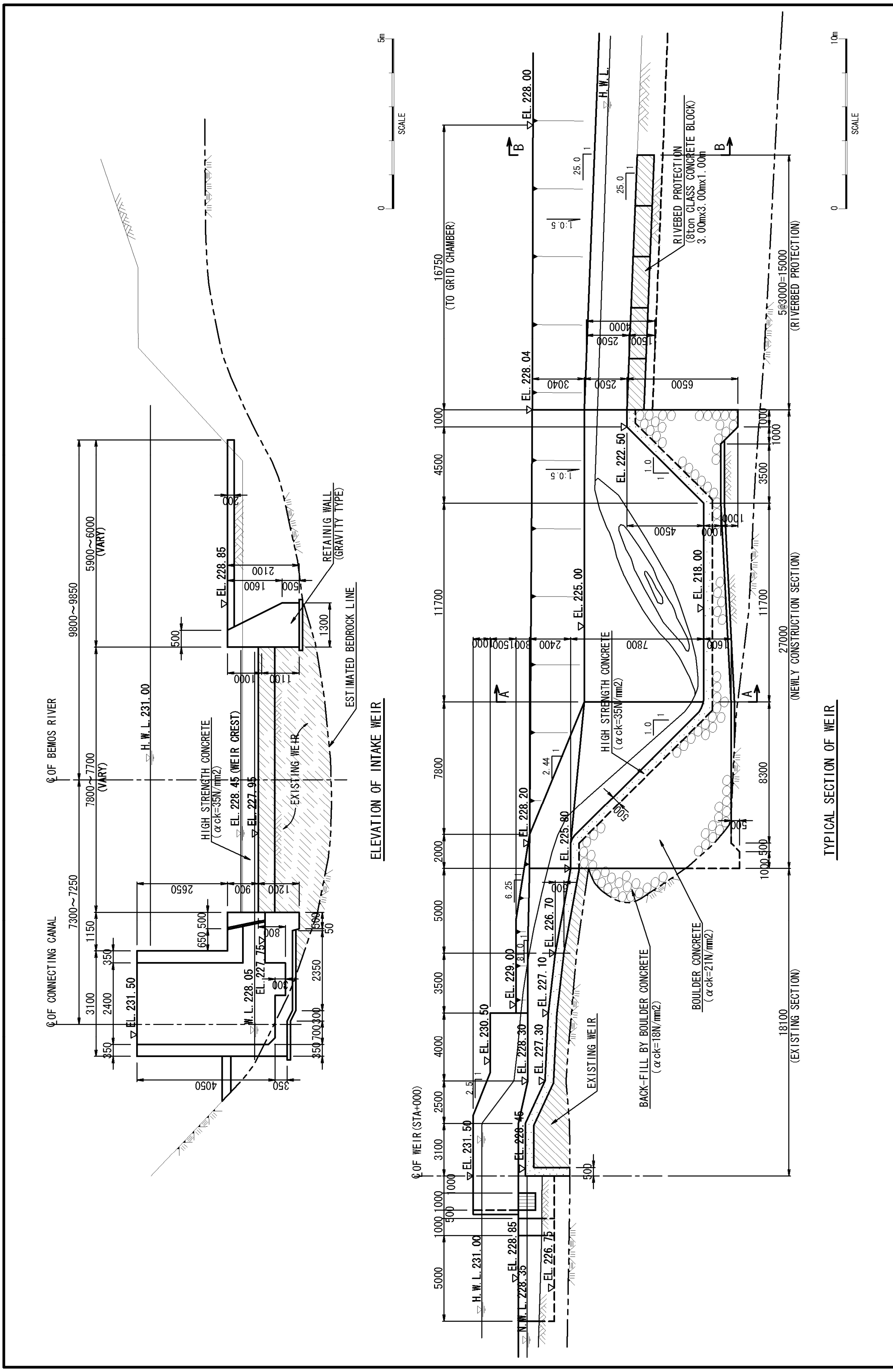
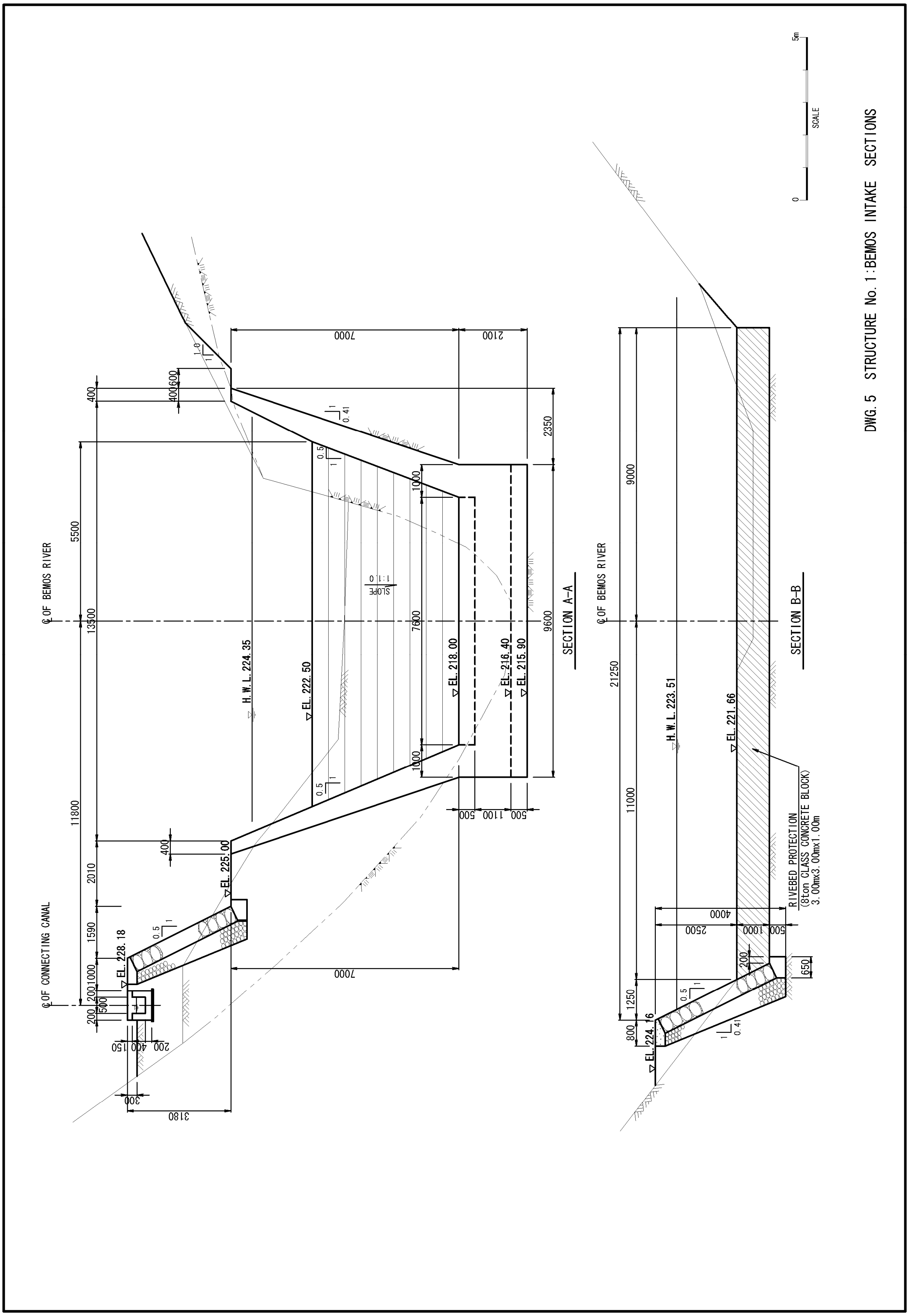
6700
6800
6900
7000
7062

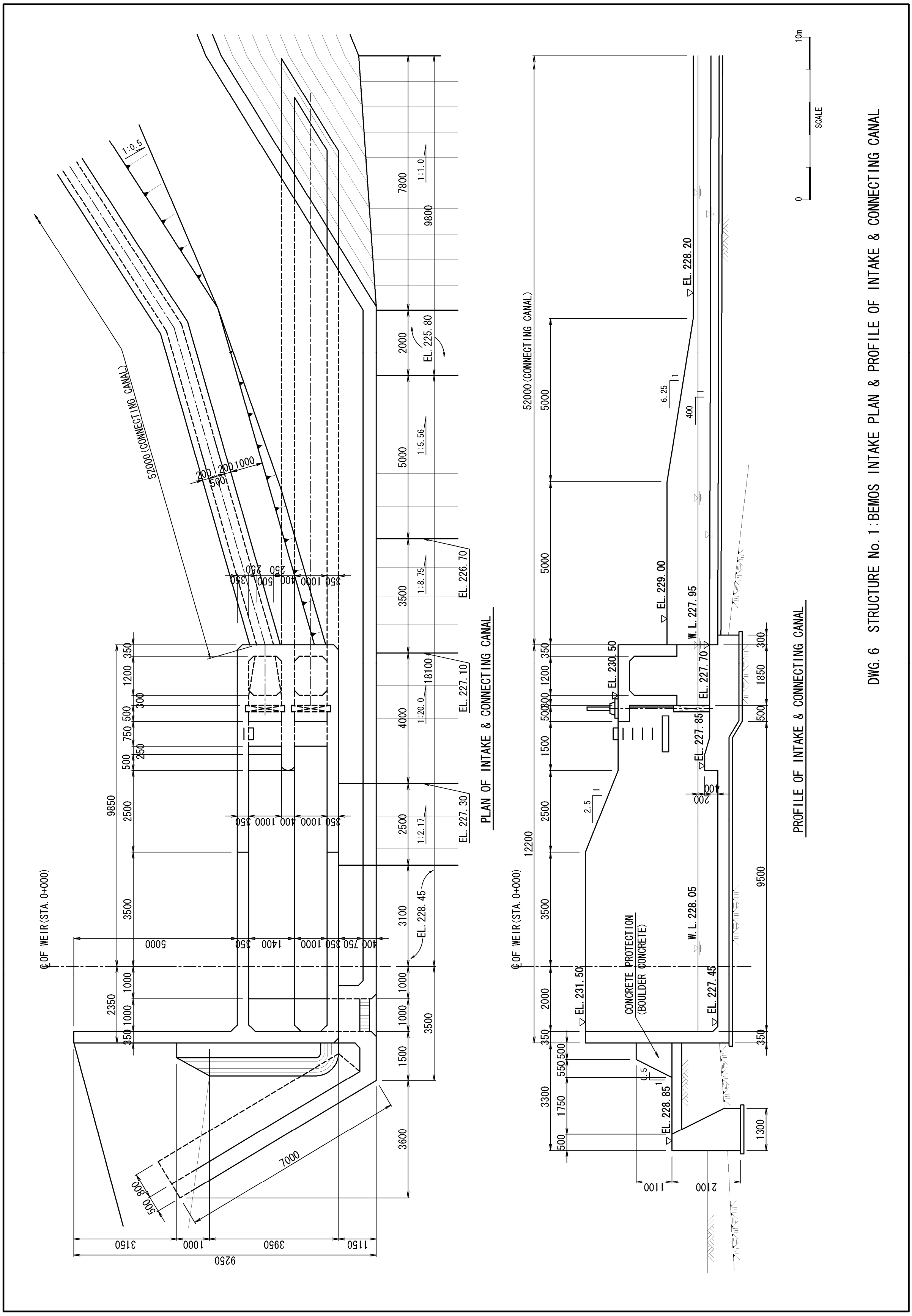

DWG. 3 STRUCTURE No. 1:BEMOS INTAKE GENERAL PLAN
SCALE
EXISTING RAW WATER MAIN
DRAINAGE CROSSING
OF WEIR (STA.0+000)
IP. 1 IA=16° 00' R=0.00 TL=0.00 CL=0.00 SL=0.00
IP. 2 IA=6° 00' R=0.00 TL=0.00 CL=0.00 SL=0.00
IP. 3 IA=24° 00' R=15.00 TL=3.19 CL=6.28 SL=0.34
IP. 4 IA=23° 00' R=15.00 TL=3.05 CL=6.02 SL=0.31



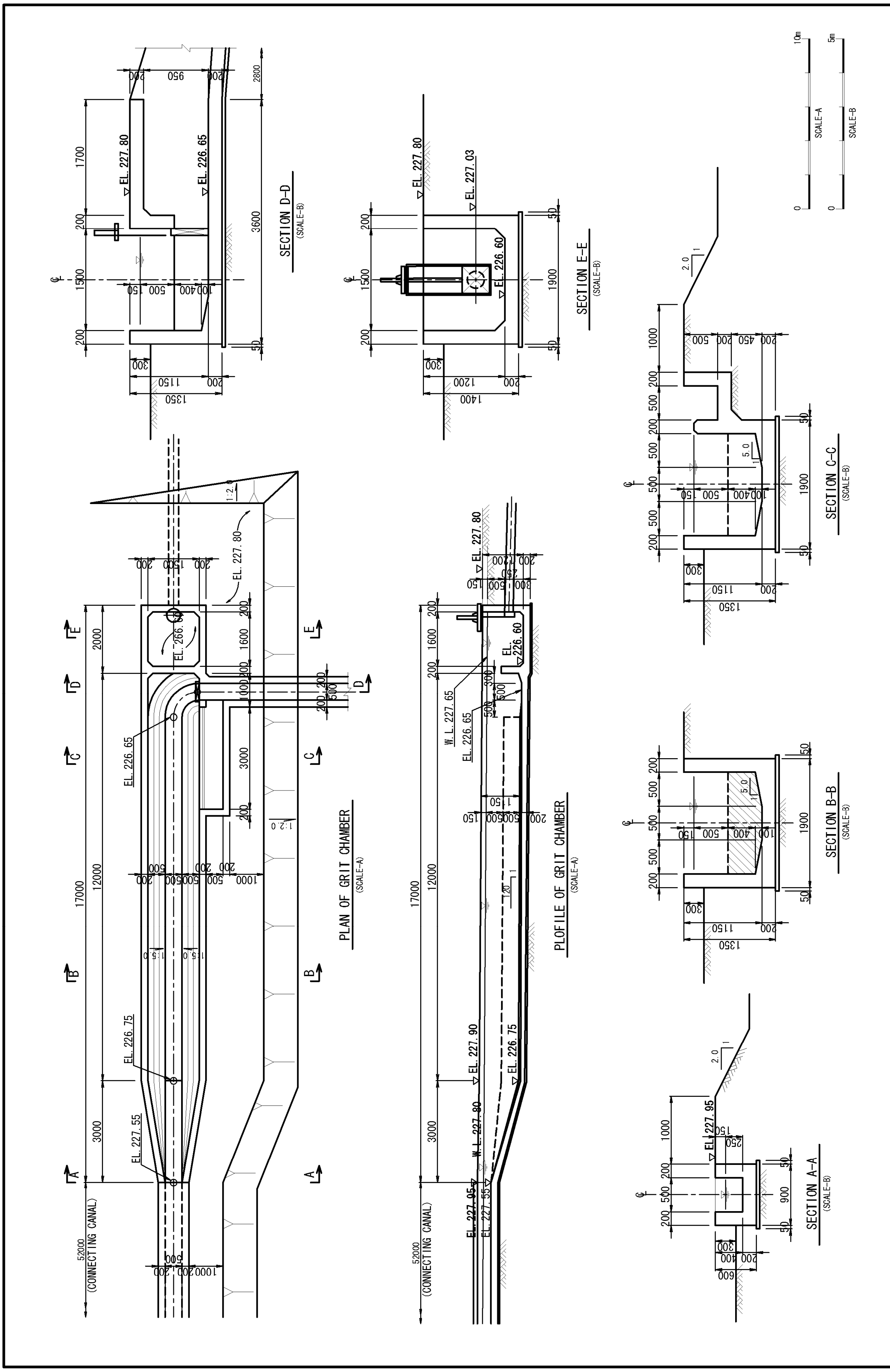
DWG. 4 STRUCTURE No. 1:BEMOS INTAKE ELEVATION & TYPICAL SECTION OF INTAKE WEIR



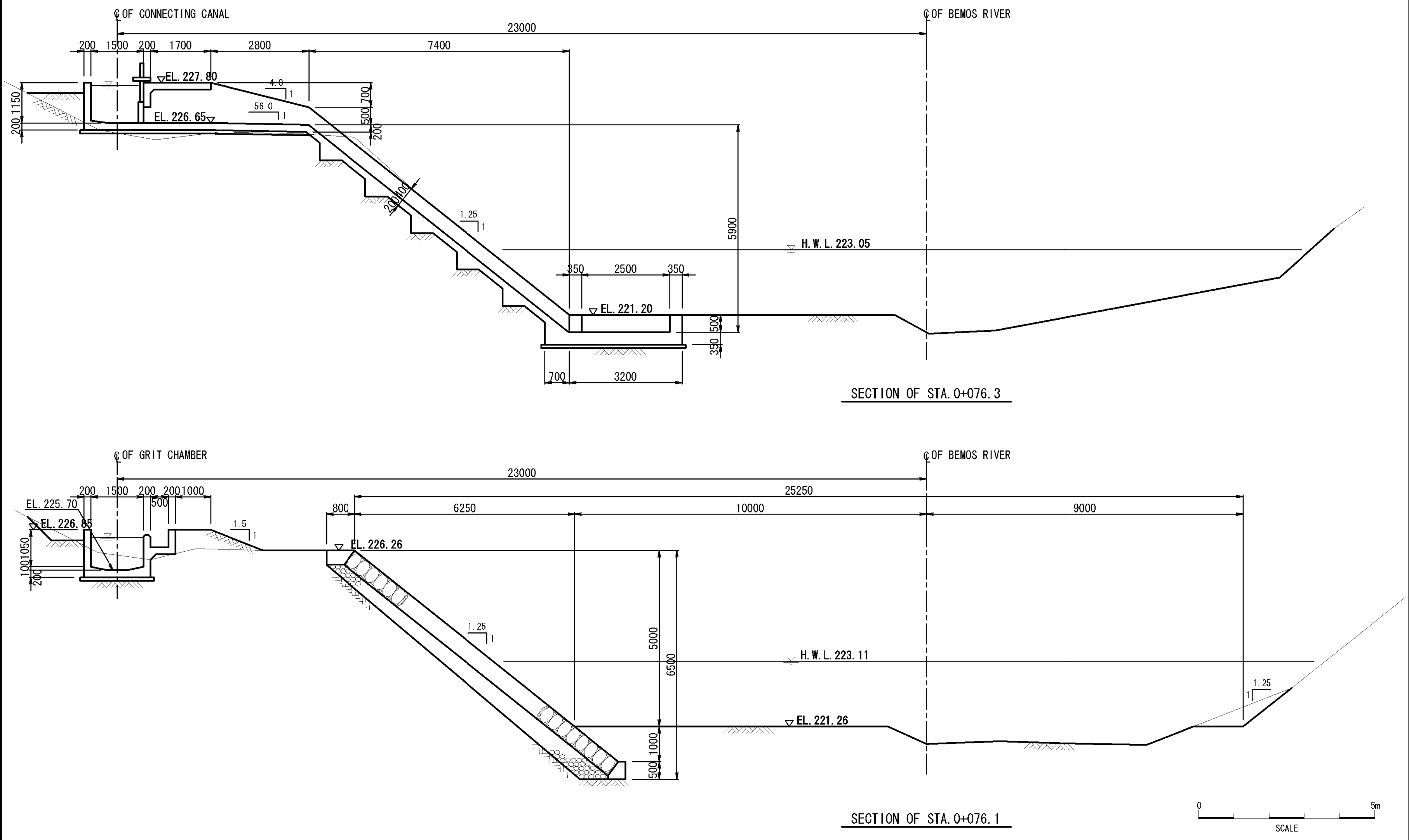
SECTION A-A
SECTION B-B
℄ OF BEMOS RIVER
℄ OF CONNECTING CANAL
H.W.L.224.35
EL.222.50
EL.218.00
EL.216.40
EL.215.90
EL.225.00
EL.228.18
H.W.L.223.51
EL.221.66
EL.224.16
SLOPE 1:1.0
RIVEBED PROTECTION
(8ton CLASS CONCRETE BLOCK)
3.00mx3.00mx1.00m
SCALE
DWG.5 STRUCTURE No.1:BEMOS INTAKE SECTIONS



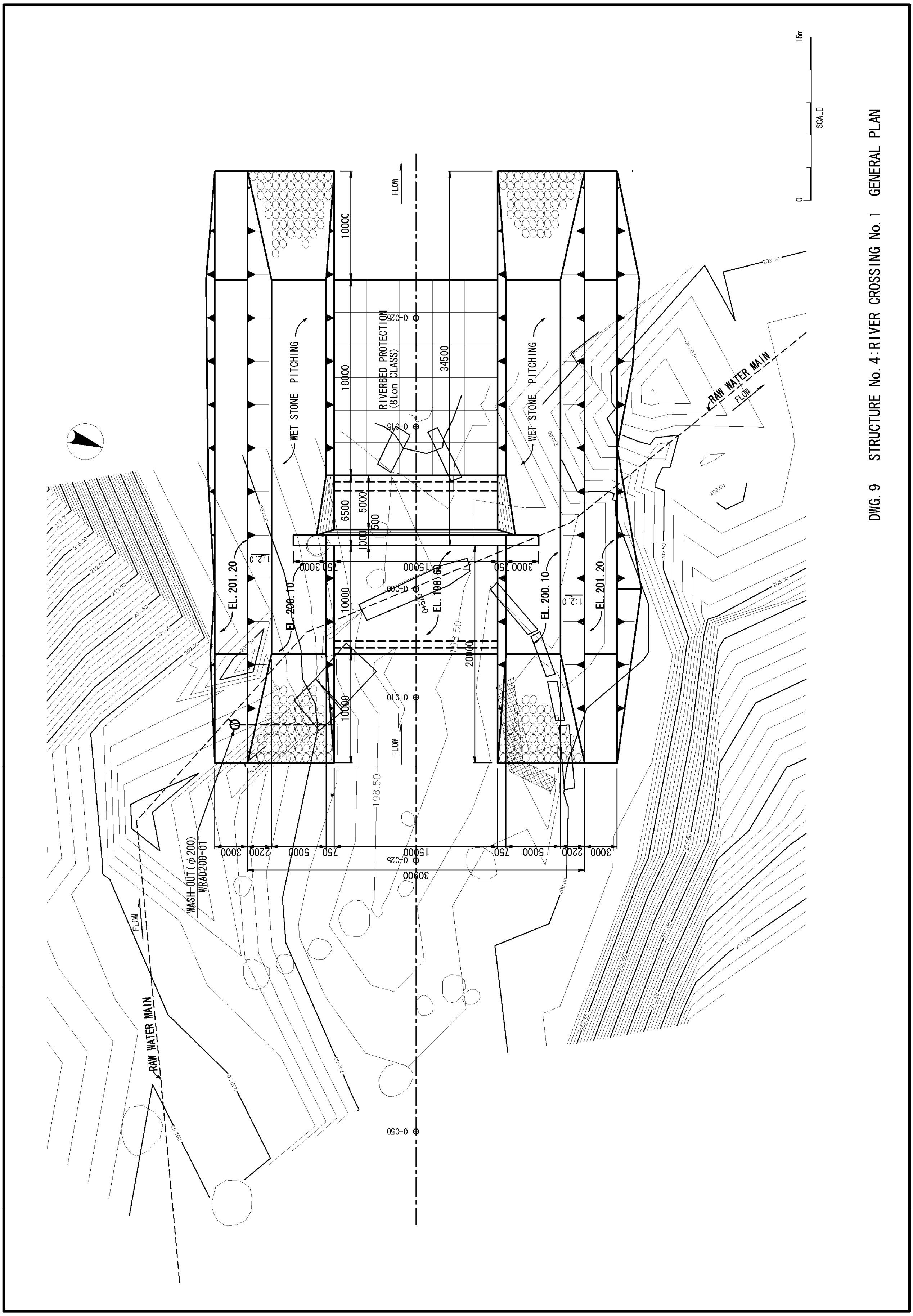
DWG. 6 STRUCTURE No. 1: BEMOS INTAKE PLAN & PROFILE OF INTAKE & CONNECTING CANAL



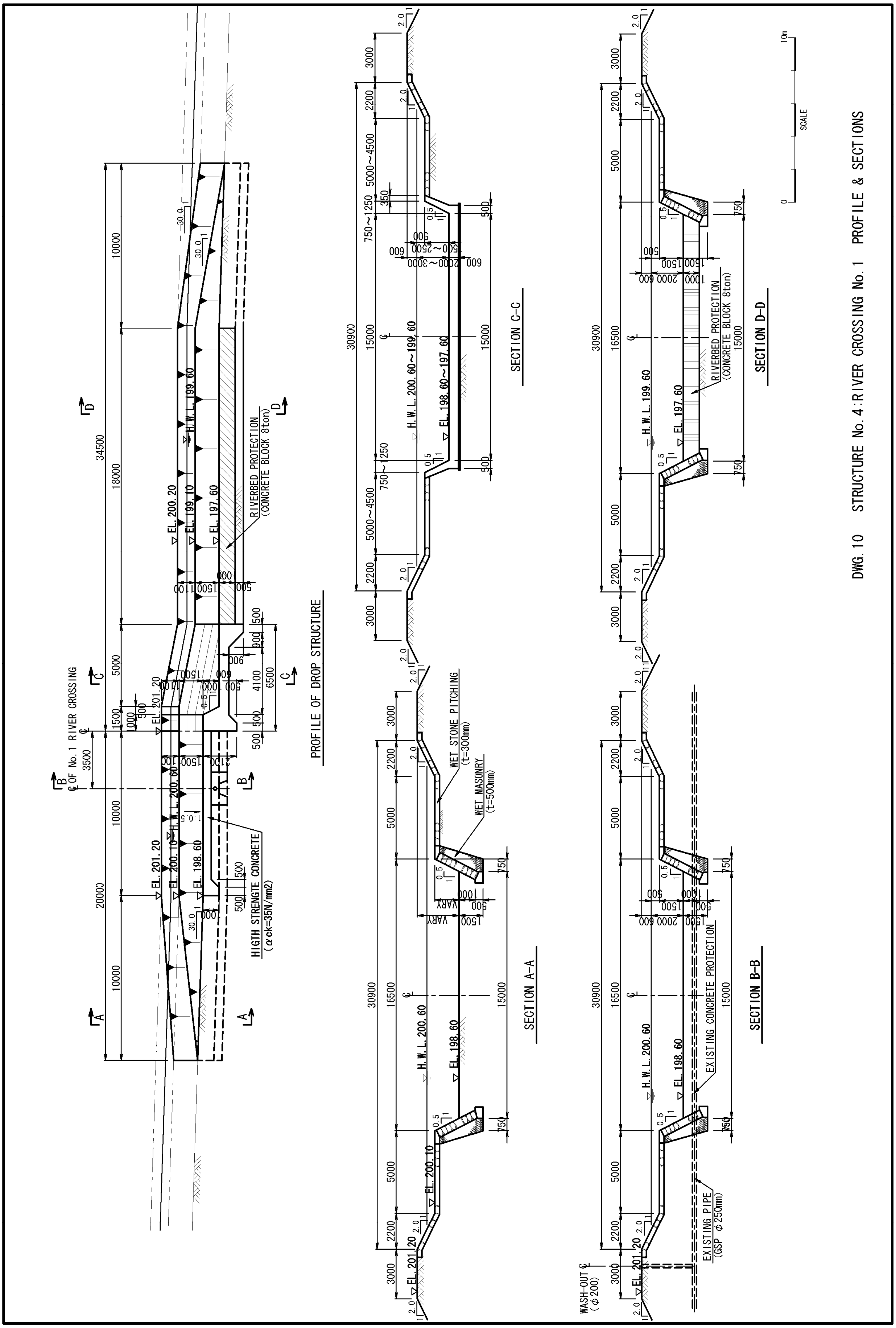
DWG. 7 STRUCTURE No. 2:GRIT CHAMBER PLAN, PROFILE & SECTIONS

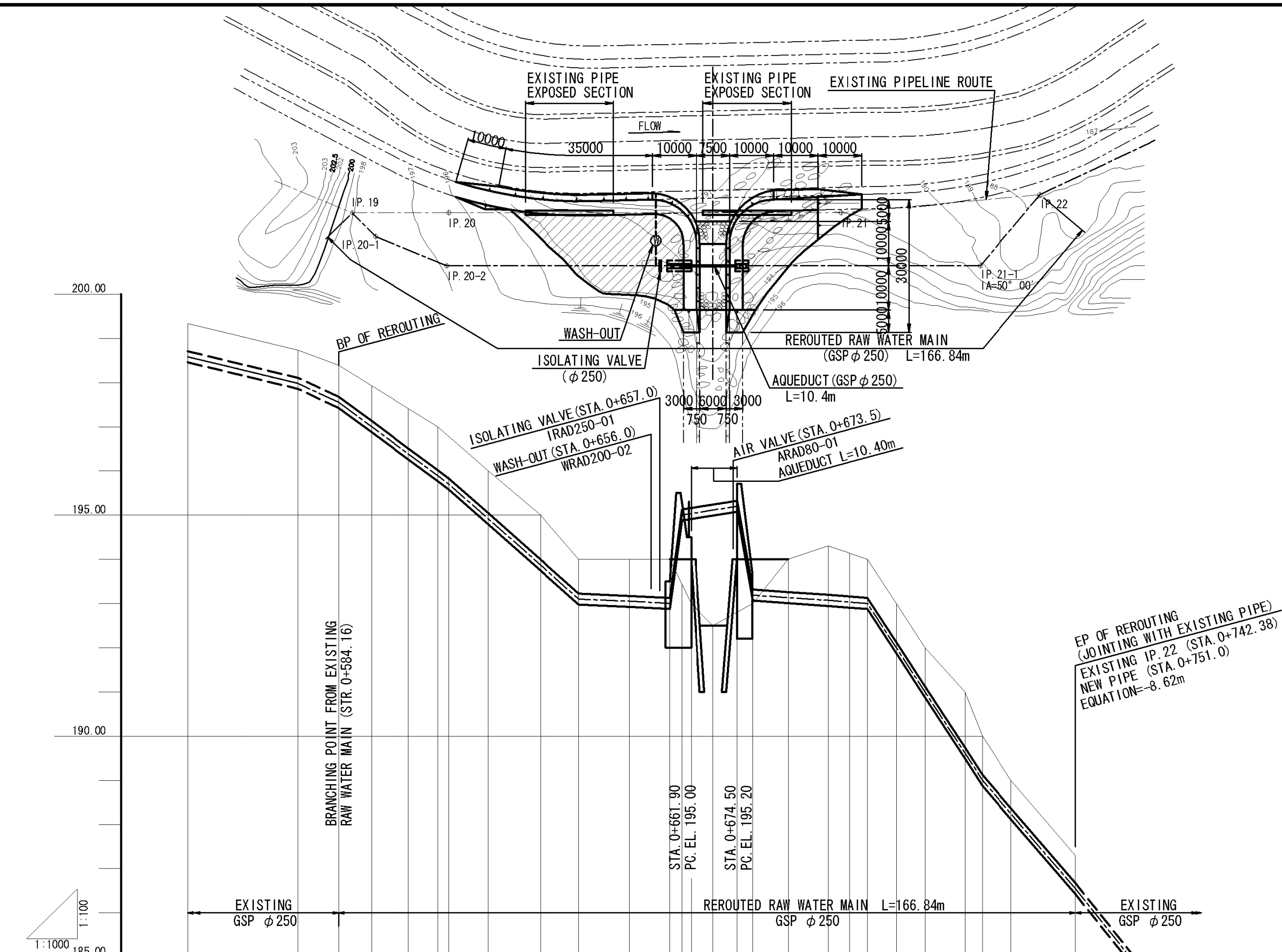


DWG. 8 STRUCTURE No. 2:GRIT CHAMBER SECTIONS



DWG. 9 STRUCTURE No. 4:RIVER CROSSING No. 1 GENERAL PLAN

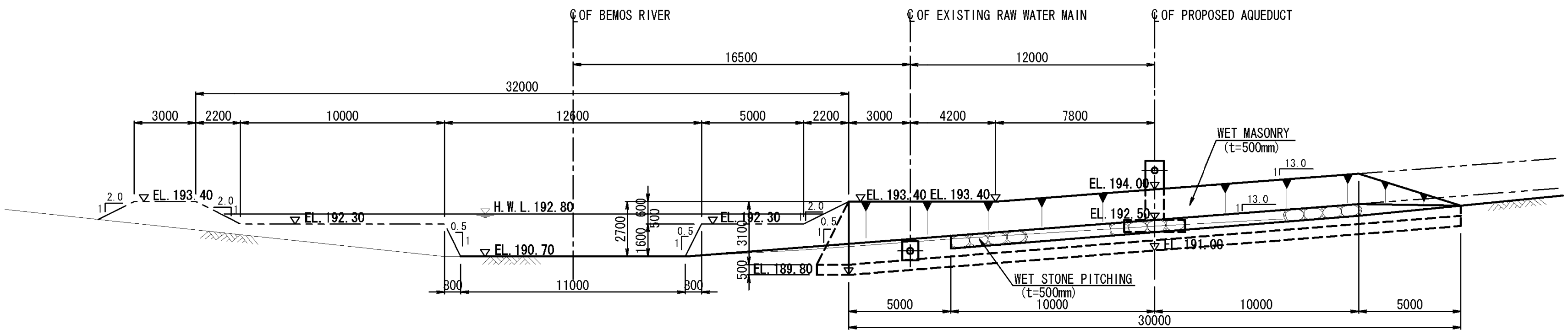

DWG. 10 STRUCTURE No. 4: RIVER CROSSING No. 1 PROFILE & SECTIONS
PROFILE OF DROP STRUCTURE
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
RIVERBED PROTECTION (CONCRETE BLOCK 8ton)
HIGTH STRENGTE CONCRETE (σck=35N/mm2)
WET STONE PITCHING (t=300mm)
WET MASONRY (t=500mm)
EXISTING CONCRETE PROTECTION
EXISTING PIPE (GSP φ250mm)
WASH-OUT (φ200)
℄ OF No. 1 RIVER CROSSING
H. W. L. 200. 60
H. W. L. 199. 60
EL. 201. 20
EL. 200. 20
EL. 200. 10
EL. 199. 10
EL. 198. 60
EL. 197. 60
SCALE
10m



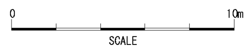
STATION NO.	ACCUMULATE DISTANCE	GROUND ELEVATION	EARTH COVERING	CENTER OF PIPE ELEVATION
0+550	550.00	199.33	0.63	198.58
0+575	575.00	198.73	0.63	197.98
IP.19	584.16	198.39	0.71	197.55
IP.20-1	591.66			197.00
0+600	600.00			196.38
	606.66	197.00	0.98	195.89
IP.20-2	609.16			195.70
	618.00	196.00	0.45	194.92
	629.90	195.00	1.00	193.87
	638.60	194.00	0.77	193.10
0+650	650.00			193.05
	659.2	194.00	0.86	193.00
	661.90			195.00
	664.00	193.00		195.08
	669.00	192.50		195.18
	674.50			195.20
	678.00	194.00 (193.0)	0.68	193.19
	686.00	194.00	0.74	193.13
	695.00	194.30	1.10	193.07
0+700	700.00			193.03
	704.00	194.00	0.87	193.00
	710.50	193.00	0.87	192.00
	717.00	192.00	0.87	191.00
	726.00	191.00	1.25	189.62
IP.21-1	730.00	190.00	0.87	189.00
	736.50	189.00	0.62	188.24
IP.22	751.00 (742.38)	187.30	0.62	186.55

HORIZONTAL 0 10.0 20.0 30.0 40.0 50.0m
VERTICAL 0 1.0 2.0 3.0 4.0 5.0m

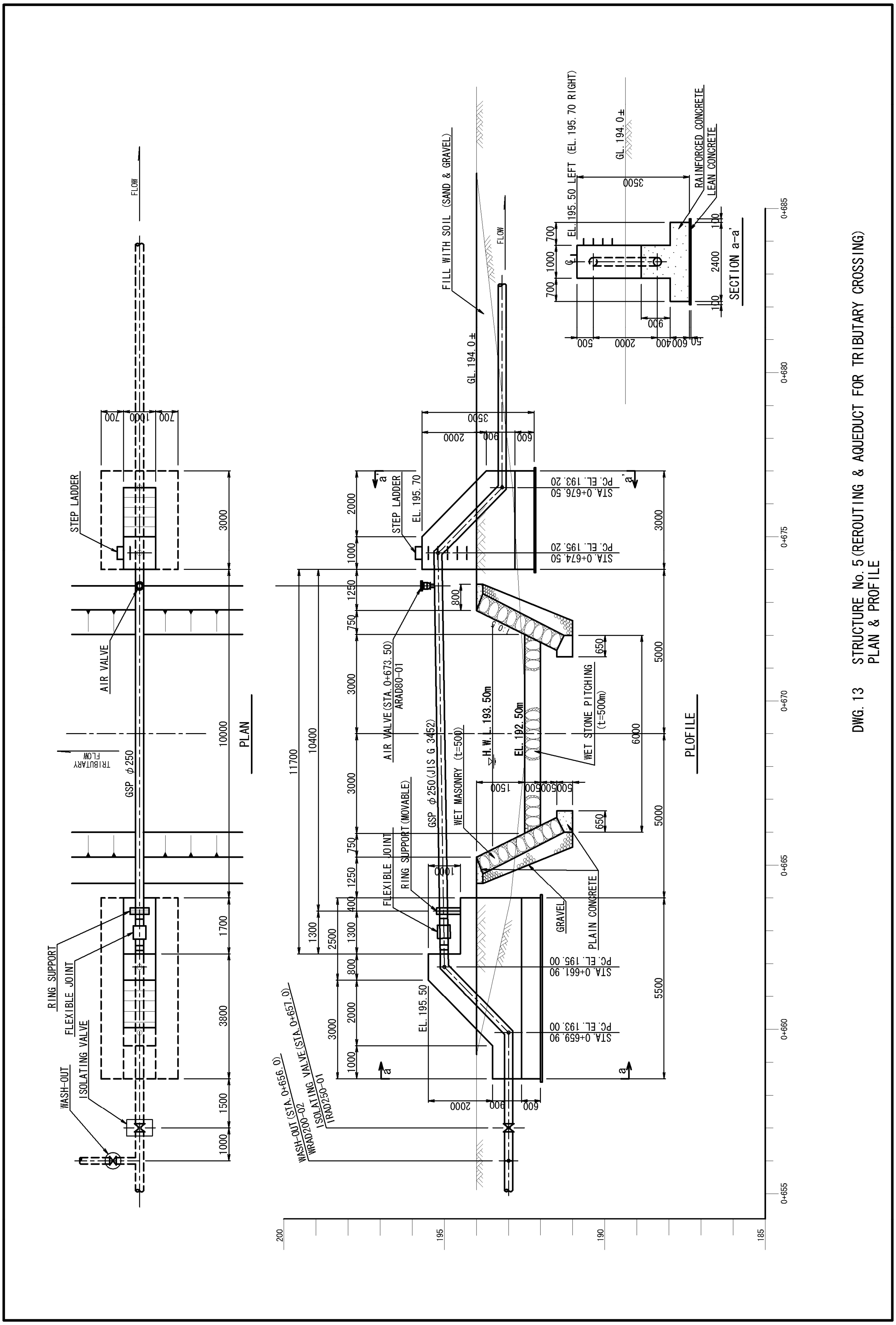
DWG.11 STRUCTURE No.5 (REROUTING & AQUEDUCT FOR TRIBUTARY CROSSING)
PLAN & PROFILE

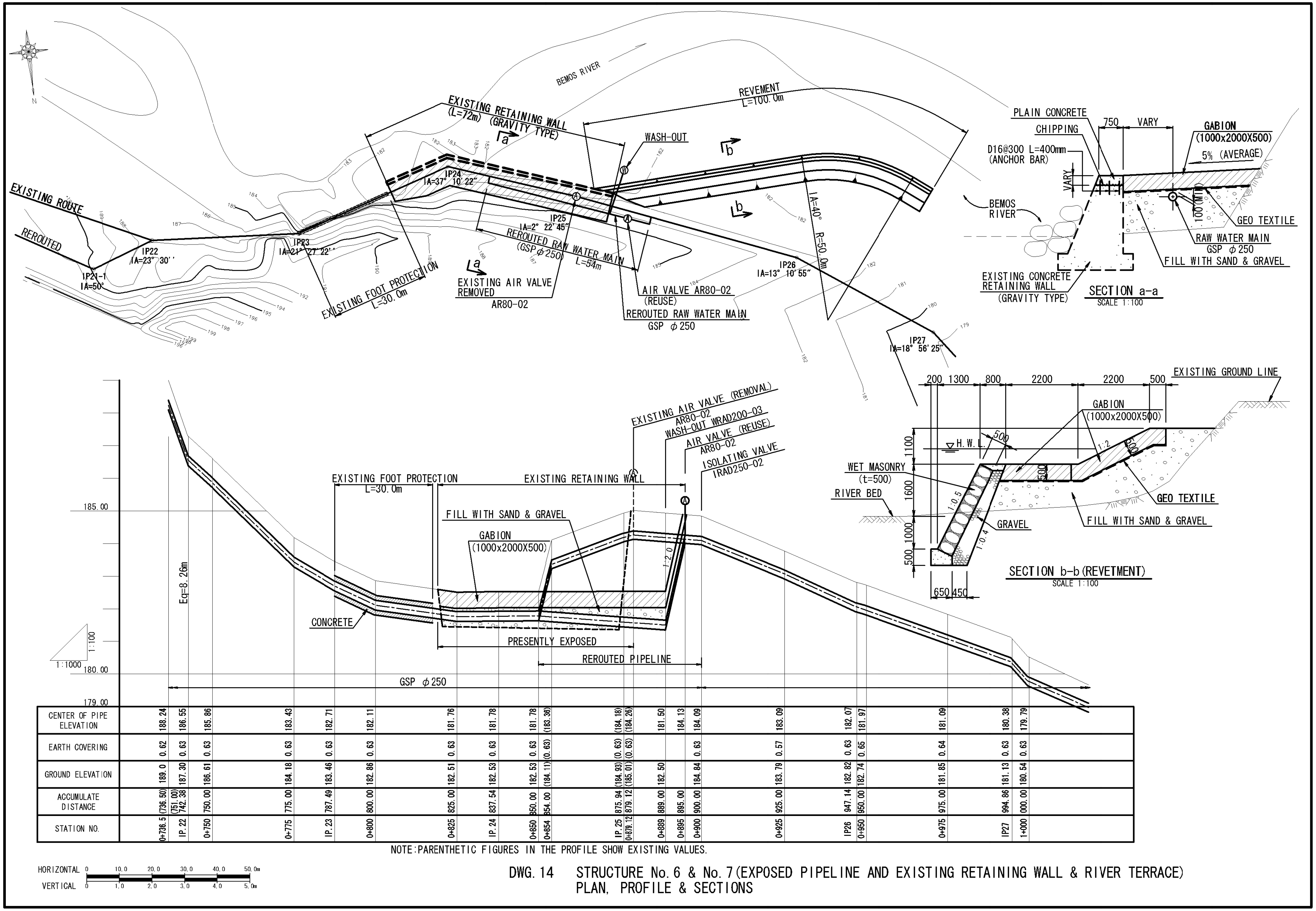


CROSS SECTION OF BEMOS RIVER & PROFILE OF TRIBUTARY



DWG. 12 STRUCTURE No. 5 (REROUTING & AQUEDUCT FOR TRIBUTARY CROSSING)
CROSS SECTION OF BEMOS RIVER & PROFILE OF TRIBUTARY


DWG. 13 STRUCTURE No. 5 (REROUTING & AQUEDUCT FOR TRIBUTARY CROSSING)
PLAN & PROFILE
PLAN
PLOFILE
SECTION a-a'
FLOW
TRIBUTARY FLOW
GSP φ250
STEP LADDER
AIR VALVE
RING SUPPORT
FLEXIBLE JOINT
ISOLATING VALVE
WASH-OUT
WASH-OUT (STA.0+656.0)
WRAD200-02
ISOLATING VALVE (STA.0+657.0)
IRAD250-01
AIR VALVE (STA.0+673.50)
ARAD80-01
GSP φ250 (JIS G 3452)
RING SUPPORT (MOVABLE)
WET MASONRY (t=500)
H.W.L. 193.50m
EL. 192.50m
WET STONE PITCHING (t=500m)
GRAVEL
PLAIN CONCRETE
FILL WITH SOIL (SAND & GRAVEL)
GL. 194.0±
EL. 195.70
EL. 195.50
PC. EL. 193.20
STA. 0+676.50
PC. EL. 195.20
STA. 0+674.50
PC. EL. 195.00
STA. 0+661.90
PC. EL. 193.00
STA. 0+659.90
EL. 195.50 LEFT (EL. 195.70 RIGHT)
RAINFORCED CONCRETE
LEAN CONCRETE
0+655
0+660
0+665
0+670
0+675
0+680
0+685
200
195
190
185

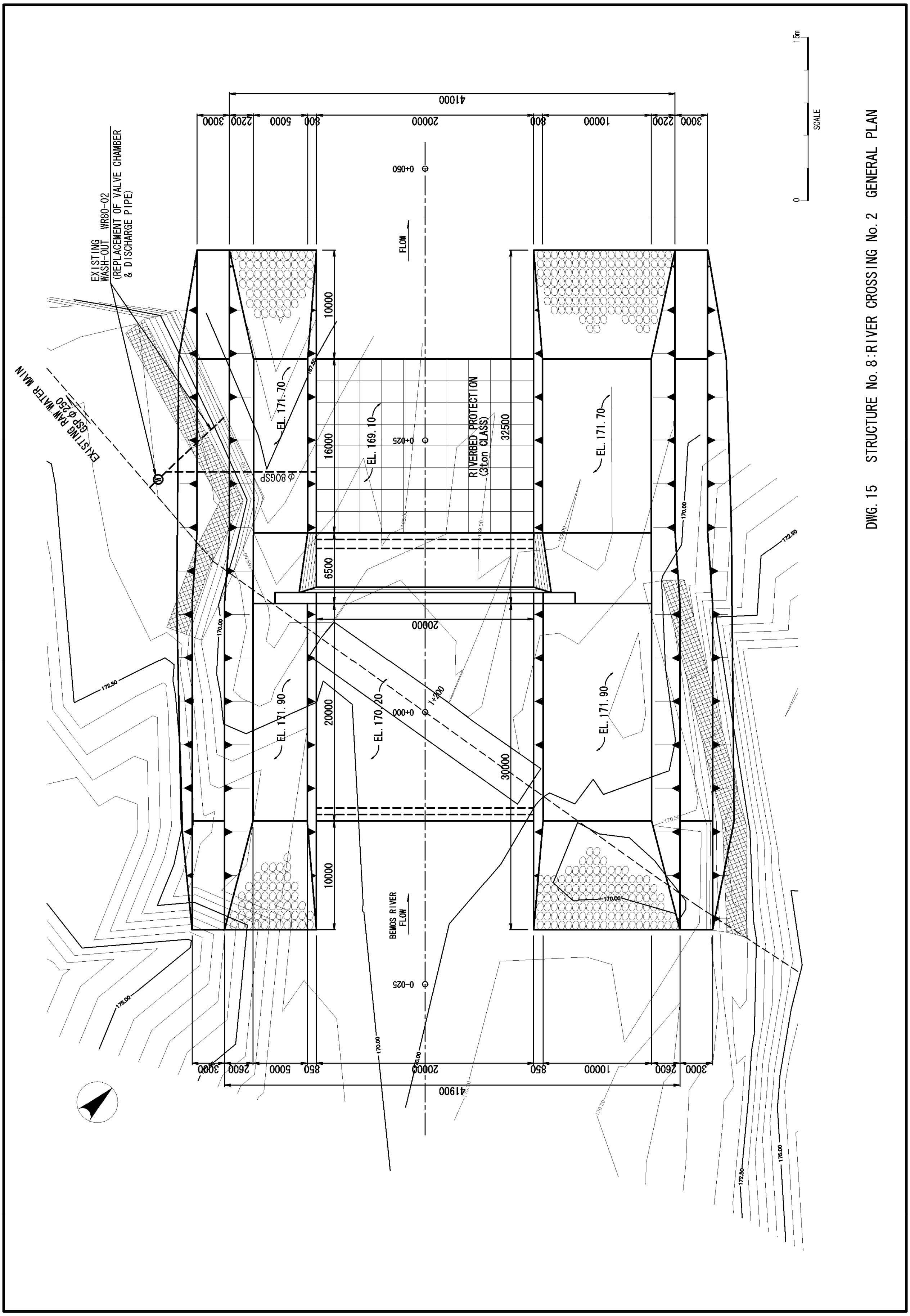


STATION NO.	ACCUMULATE DISTANCE	GROUND ELEVATION	EARTH COVERING	CENTER OF PIPE ELEVATION
0+736.5	(736.50)	189.0	0.62	188.24
IP.22	(751.00) 742.38	187.30	0.63	186.55
0+750	750.00	186.61	0.63	185.86
0+775	775.00	184.18	0.63	183.43
IP.23	787.49	183.46	0.63	182.71
0+800	800.00	182.86	0.63	182.11
0+825	825.00	182.51	0.63	181.76
IP.24	837.54	182.53	0.63	181.78
0+850	850.00	182.53	0.63	181.78
0+854	854.00	(184.11)	(0.63)	(183.36)
IP.25	875.94	(184.93)	(0.63)	(184.18)
0+879.12	879.12	(185.01)	(0.63)	(184.26)
0+889	889.00	182.50		181.50
0+895	895.00			184.13
0+900	900.00	184.84	0.63	184.09
0+925	925.00	183.79	0.57	183.09
IP26	947.14	182.82	0.63	182.07
0+950	950.00	182.74	0.65	181.97
0+975	975.00	181.85	0.64	181.09
IP27	994.86	181.13	0.63	180.38
1+000	000.00	180.54	0.63	179.79

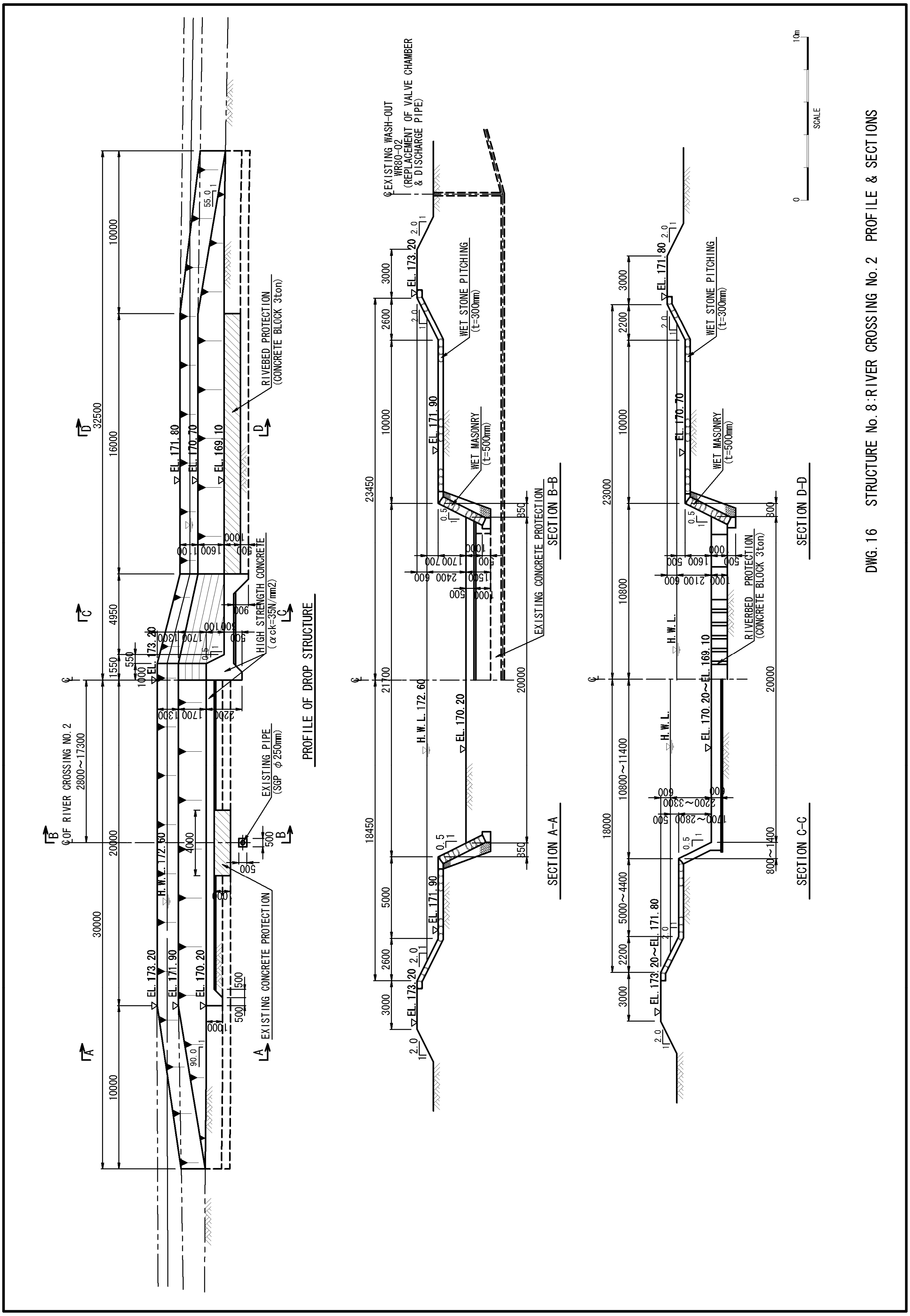
NOTE:PARENTHETIC FIGURES IN THE PROFILE SHOW EXISTING VALUES.

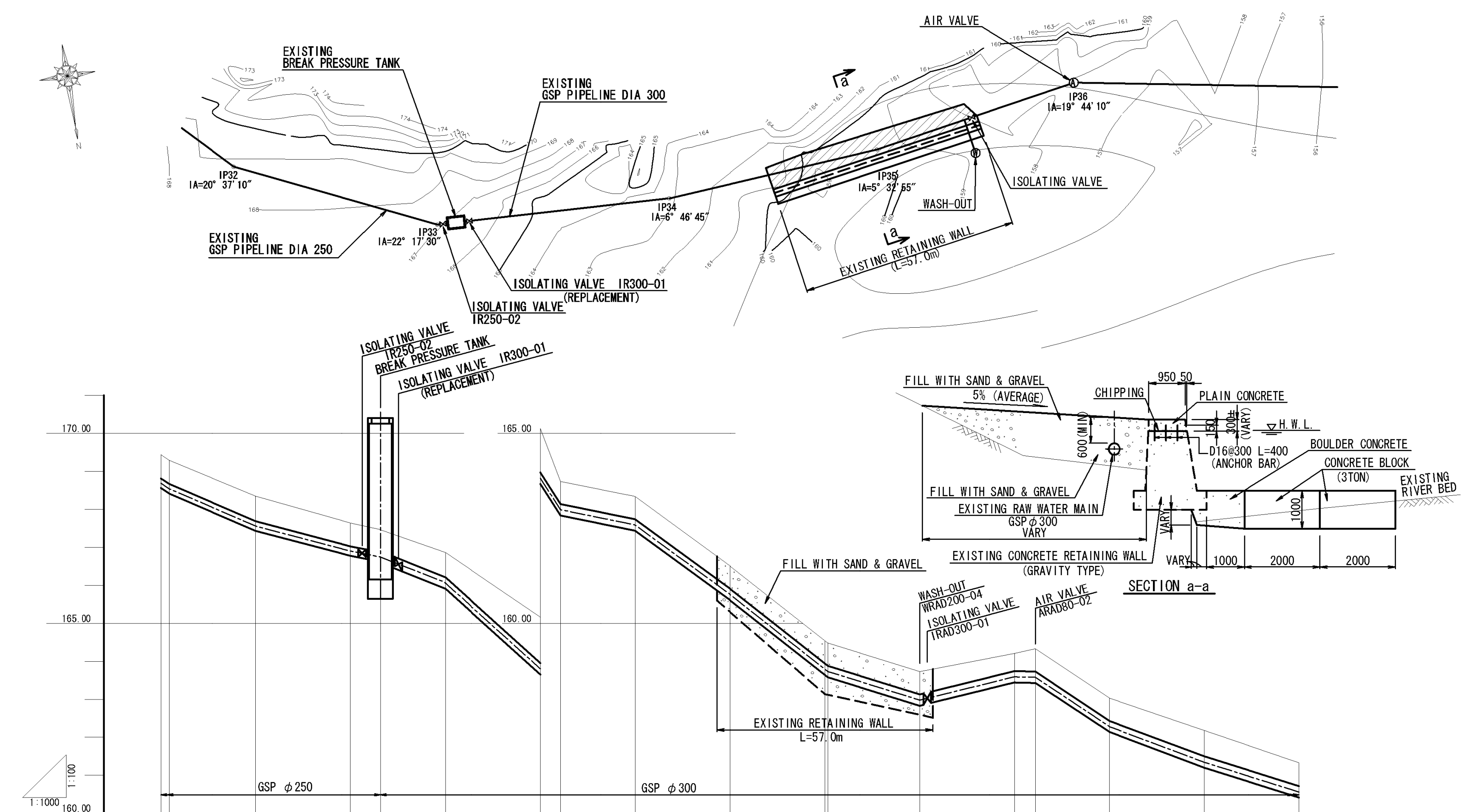
HORIZONTAL 0 10.0 20.0 30.0 40.0 50.0m
VERTICAL 0 1.0 2.0 3.0 4.0 5.0m

DWG.14 STRUCTURE No.6 & No.7(EXPOSED PIPELINE AND EXISTING RETAINING WALL & RIVER TERRACE)
PLAN, PROFILE & SECTIONS



DWG. 15 STRUCTURE No. 8:RIVER CROSSING No. 2 GENERAL PLAN

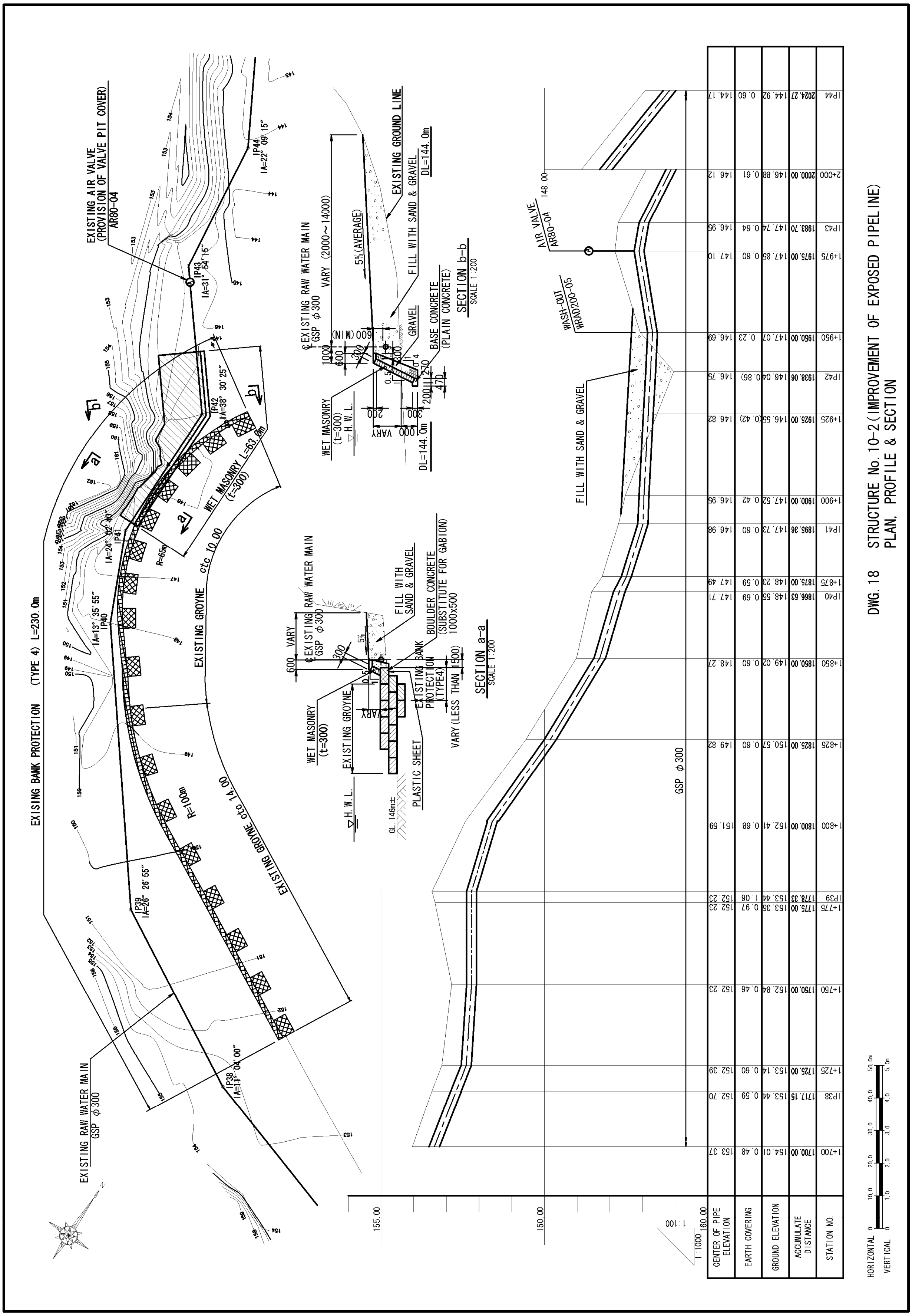

DWG.16 STRUCTURE No.8:RIVER CROSSING No.2 PROFILE & SECTIONS
PROFILE OF DROP STRUCTURE
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
℄ OF RIVER CROSSING NO.2
2800~17300
EXISTING PIPE
(SGP φ250mm)
EXISTING CONCRETE PROTECTION
HIGH STRENGTH CONCRETE
(σck=35N/mm2)
RIVEBED PROTECTION
(CONCRETE BLOCK 3ton)
RIVERBED PROTECTION
(CONCRETE BLOCK 3ton)
WET STONE PITCHING
(t=300mm)
WET MASONRY
(t=500mm)
℄ EXISTING WASH-OUT
WR80-02
(REPLACEMENT OF VALVE CHAMBER
& DISCHARGE PIPE)
H.W.L.172.60
EL.173.20
EL.171.90
EL.170.20
EL.171.80
EL.170.70
EL.169.10
SCALE
10m

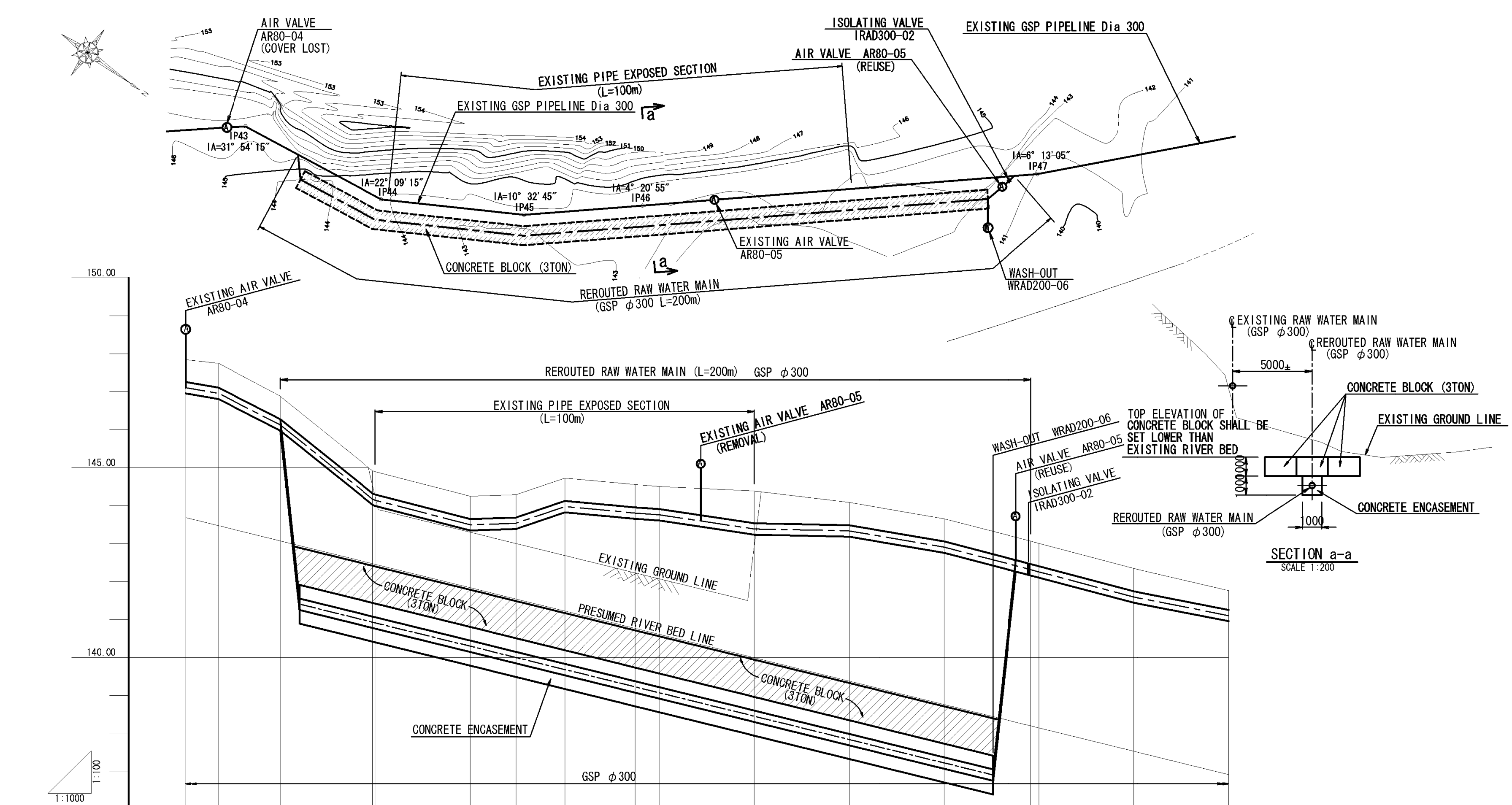


CENTER OF PIPE ELEVATION	168.69	168.54	167.59	166.91	166.72	166.09	163.82	162.99	162.59	160.76	158.79	158.73	157.98	158.59	158.58	157.28	156.34	155.56
EARTH COVERING	0.63	0.63	0.64	0.60	0.63	0.60	1.19	0.60	0.60	0.60	0.60	0.60	0.60	0.47	0.60	0.60	0.69	0.62
GROUND ELEVATION	169.44	169.29	168.35	167.64	167.47	166.84	165.16	163.74	163.34	161.51	159.54	159.48	158.73	159.21	159.33	158.03	157.18	156.33
ACCUMULATE DISTANCE	1300.00	1302.23	1325.00	1350.00	1357.95	1375.00	1400.00	1419.43	1425.00	1450.00	1475.00	1475.76	1500.00	1525.00	1530.48	1550.00	1575.00	1600.00
STATION NO.	1+300	IP32	1+325	1+350	IP33	1+375	1+400	IP34	1+425	1+450	1+475	IP35	1+500	1+525	IP36	1+550	1+575	1+600

HORIZONTAL 0 10.0 20.0 30.0 40.0 50.0m
VERTICAL 0 1.0 2.0 3.0 4.0 5.0m

DWG. 17 STRUCTURE No. 10-1(EXPOSED PIPELINE & EXISTING RETAINING WALL)
PLAN, PROFILE & SECTION

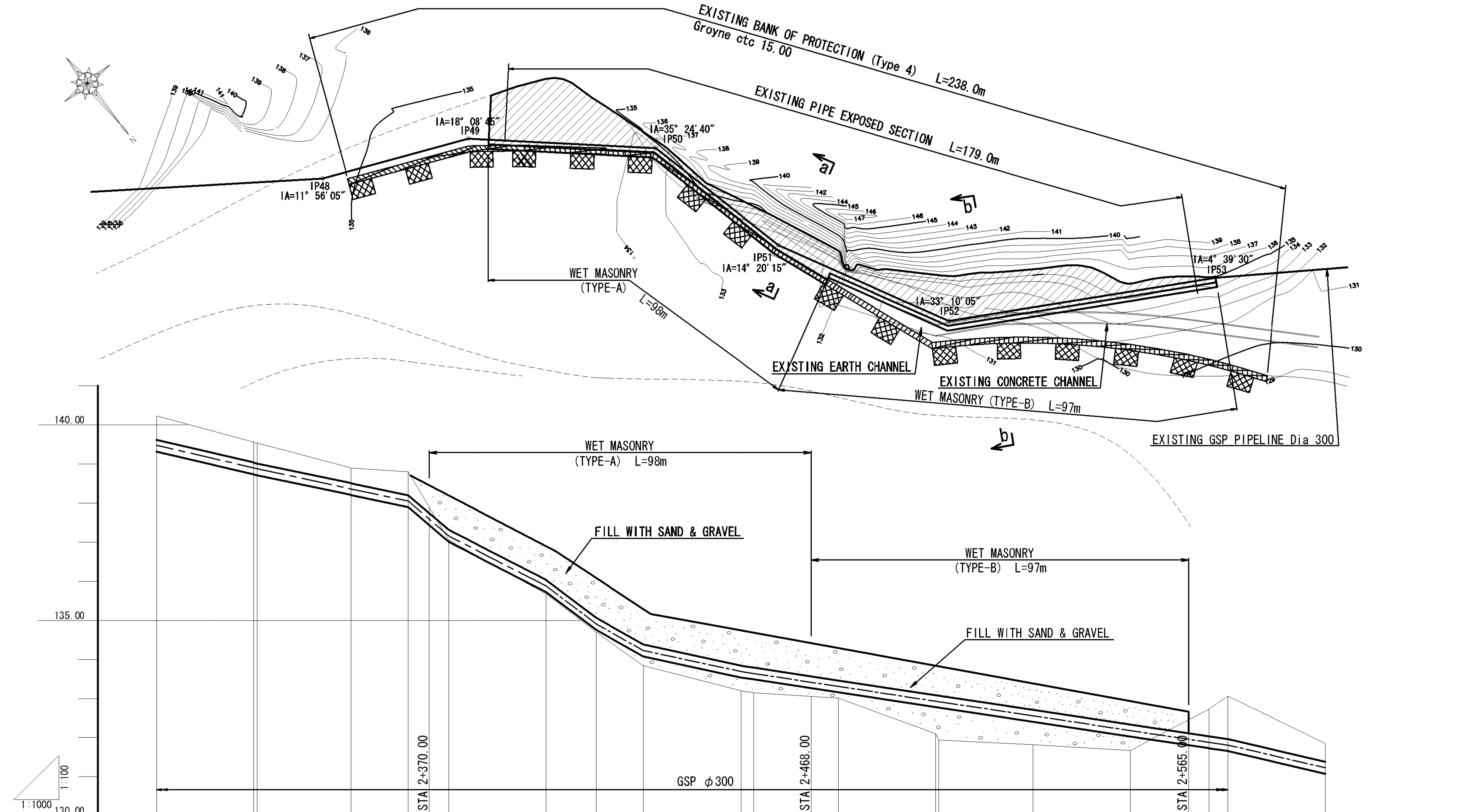

EXISING BANK PROTECTION (TYPE 4) L=230.0m
EXISTING AIR VALVE
(PROVISION OF VALVE PIT COVER)
AR80-04
EXISTING RAW WATER MAIN
GSP φ300
EXISTING GROYNE ctc 10.00
EXISTING GROYNE ctc 14.00
WET MASONRY L=63.0m
(t=300)
R=65m
R=100m
IP38
IP39
IP40
IP41
IP42
IP43
IP44
SECTION a-a
SCALE 1:200
SECTION b-b
SCALE 1:200
EXISTING RAW WATER MAIN
GSP φ300
FILL WITH SAND & GRAVEL
BOULDER CONCRETE
(SUBSTITUTE FOR GABION)
1000x500
EXISTING BANK PROTECTION (TYPE4)
VARY (LESS THAN 1500)
WET MASONRY
(t=300)
EXISTING GROYNE
PLASTIC SHEET
H.W.L.
EXISTING GROUND LINE
DL=144.0m
VARY (2000~14000)
5% (AVERAGE)
GRAVEL
BASE CONCRETE
(PLAIN CONCRETE)
AIR VALVE
AR80-04
WASH-OUT
WRAD200-05
FILL WITH SAND & GRAVEL
GSP φ300
CENTER OF PIPE ELEVATION
EARTH COVERING
GROUND ELEVATION
ACCUMULATE DISTANCE
STATION NO.
HORIZONTAL
VERTICAL
DWG. 18 STRUCTURE No. 10-2 (IMPROVEMENT OF EXPOSED PIPELINE)
PLAN, PROFILE & SECTION



STATION NO.	1+975	IP43	2+000	IP44	2+025	2+050	IP45	2+075	IP46	2+100	2+125	2+150	2+175	IP47	2+200	2+225	2+250
CENTER OF PIPE ELEVATION	147.10	146.95	146.12	144.17	144.14	143.49	143.53	143.97	143.80	143.75	143.63	143.33	142.90	142.31	142.25	141.59	141.01
EARTH COVERING	0.60	0.64	0.61	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
GROUND ELEVATION	147.85	147.74	146.88	144.92	144.89	144.24	144.28	144.72	144.55	144.50	144.38	144.08	143.65	143.06	143.00	142.34	141.76
ACCUMULATE DISTANCE	1975.00	1983.70	2000.00	2024.27	2025.00	2050.00	2062.14	2075.00	2093.50	2100.00	2125.00	2150.00	2175.00	2197.94	2200.00	2225.00	2250.00

HORIZONTAL 0 10.0 20.0 30.0 40.0 50.0m
VERTICAL 0 1.0 2.0 3.0 4.0 5.0m

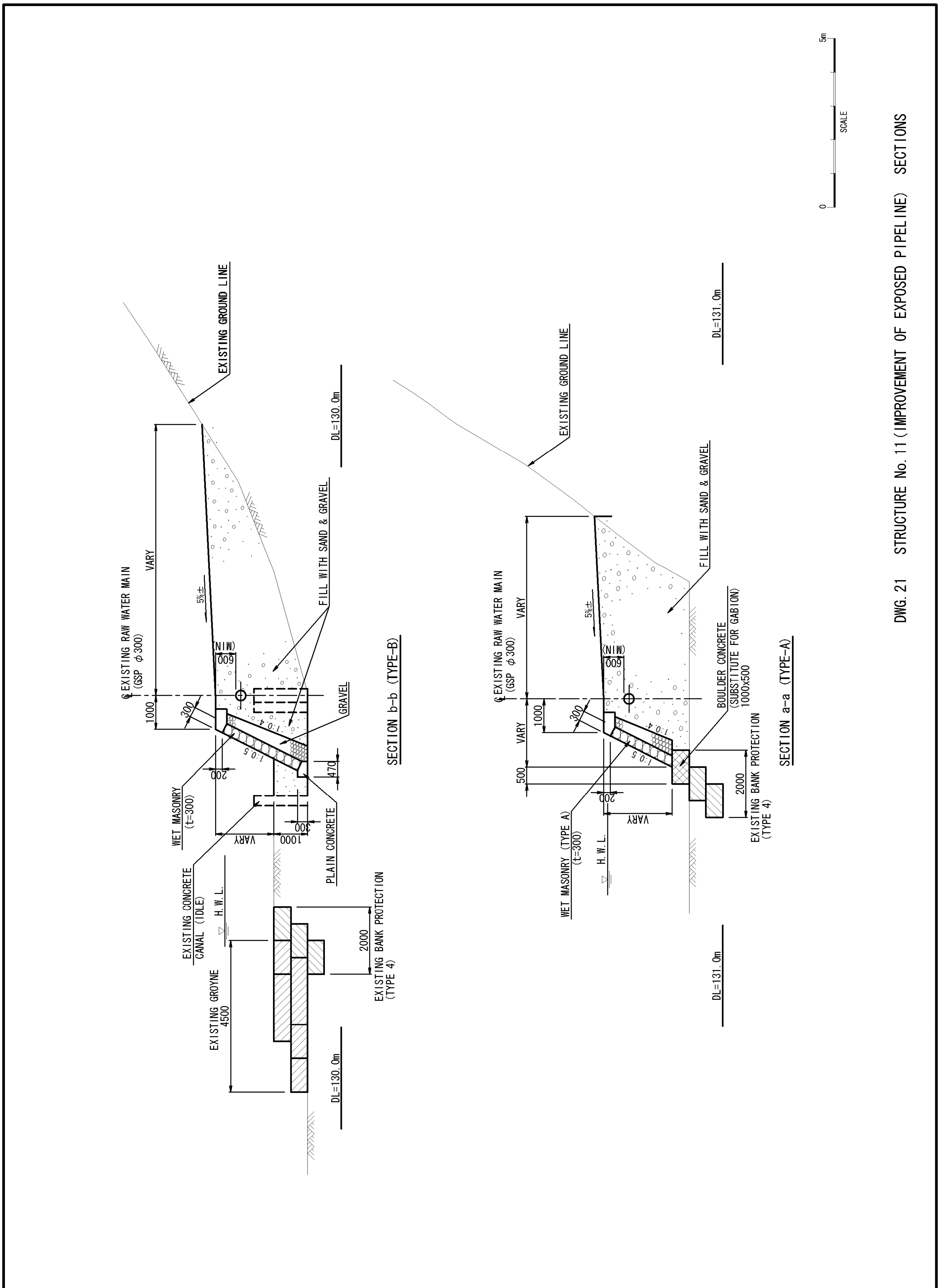
DWG.19 STRUCTURE No.10-3 (IMPROVEMENT OF EXPOSED PIPELINE BY REROUTING UNDER RIVER BED)
PLAN, PROFILE & SECTION



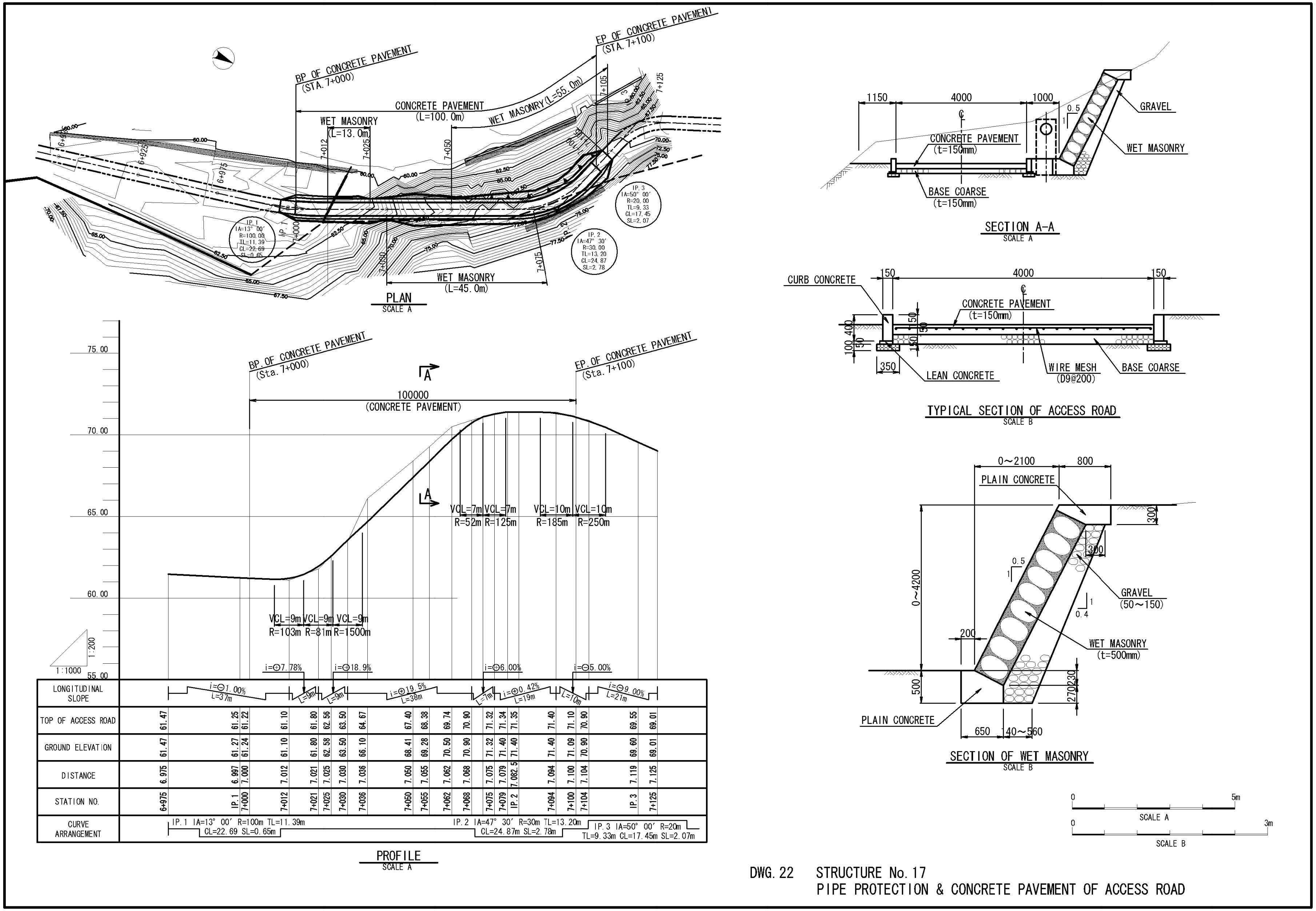
STATION NO.	2+300	2+325	IP48	2+350	IP49	2+370	2+375	2+400	IP50	2+425	2+450	IP51	2+468	2+475	2+500	IP52	2+525	2+550	2+565	IP.53	2+575	2+600
CENTER OF PIPE ELEVATION	139.48	138.90	138.88	138.36	138.05		137.16	135.88	134.91	134.23	133.69	133.64		133.31	133.06	132.92	132.56	132.18		131.88	131.81	131.23
EARTH COVERING	0.60	0.51	0.51	0.39	0.60		(0.26)	(0.35)	(0.36)	(0.54)	(0.63)	(0.64)		(0.45)	(0.81)	(1.13)	(0.89)	(0.67)		0.70	1.10	0.47
GROUND ELEVATION	140.23	139.56	139.54	138.90	138.80		137.05	135.68	134.70	133.84	133.20	133.15		133.01	132.10	131.94	131.82	131.67		132.73	133.06	131.85
ACCUMULATE DISTANCE	2300.00	2325.00	2325.82	2350.00	2364.63	2370.00	2375.00	2400.00	2412.90	2425.00	2450.00	2453.00	2468.00	2475.00	2500.00	2500.78	2525.00	2550.00	2565.00	2570.17	2575.00	2600.00

HORIZONTAL 0 10.0 20.0 30.0 40.0 50.0m
VERTICAL 0 1.0 2.0 3.0 4.0 5.0m

DWG.20 STRUCTURE No.11(IMPROVEMENT OF EXPOSED PIPELINE) PLAN & PROFILE



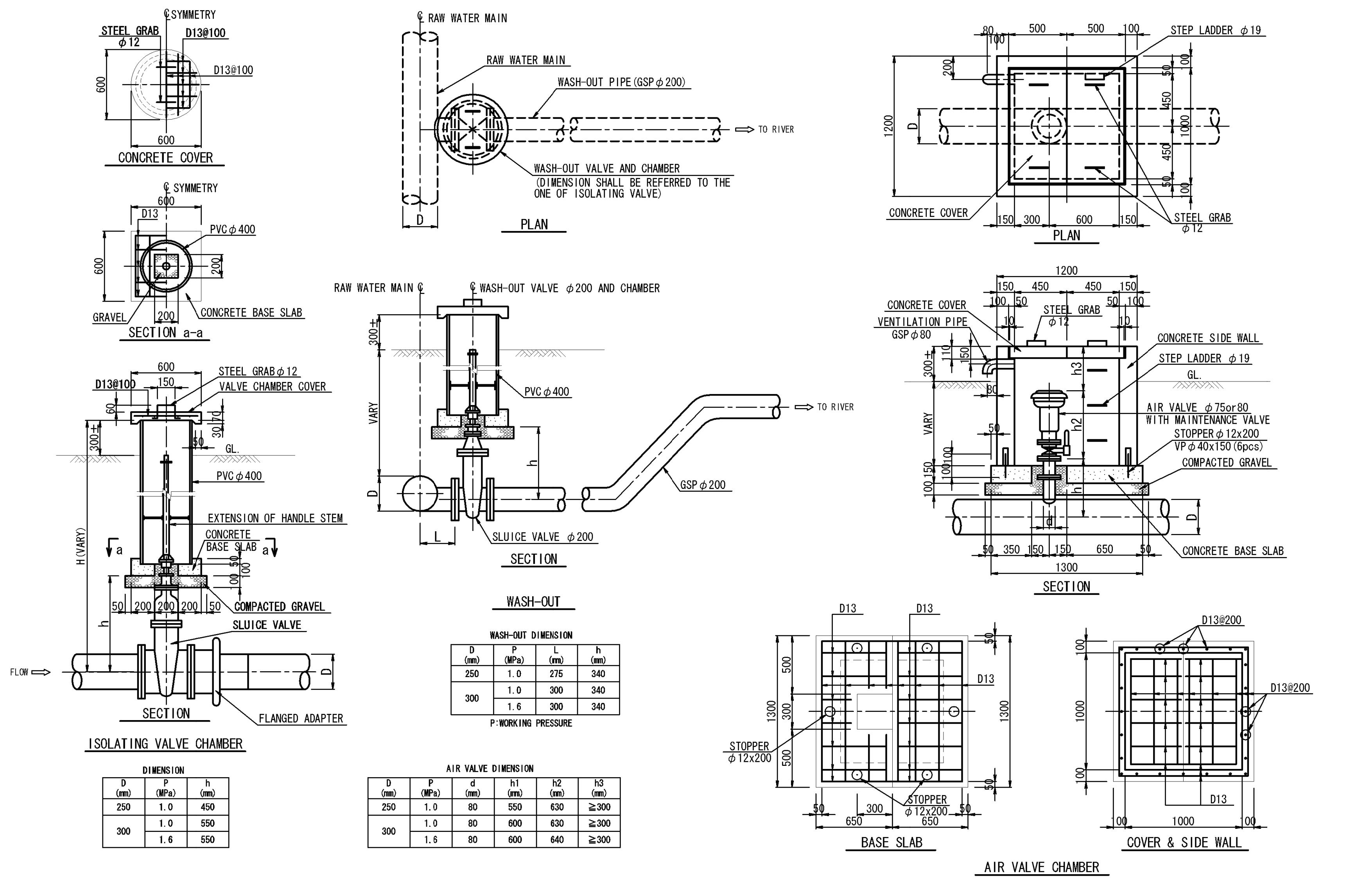
DWG. 21 STRUCTURE No. 11 (IMPROVEMENT OF EXPOSED PIPELINE) SECTIONS
SCALE
0
5m
EXISTING GROUND LINE
DL=130.0m
FILL WITH SAND & GRAVEL
℄ EXISTING RAW WATER MAIN (GSP φ300)
VARY
5%±
600 (MIN)
1000
300
1:0.4
1:0.5
GRAVEL
470
200
300
1000
WET MASONRY (t=300)
PLAIN CONCRETE
EXISTING CONCRETE CANAL (IDLE)
H.W.L.
EXISTING GROYNE 4500
2000
EXISTING BANK PROTECTION (TYPE 4)
SECTION b-b (TYPE-B)
DL=131.0m
BOULDER CONCRETE (SUBSTITUTE FOR GABION) 1000x500
500
WET MASONRY (TYPE A) (t=300)
SECTION a-a (TYPE-A)



TOP OF ACCESS ROAD	61.47	61.25	61.22	61.10	61.80	62.56	63.50	64.67	67.40	68.38	69.74	70.90	71.32	71.34	71.35	71.40	71.10	70.90	69.55	69.01
GROUND ELEVATION	61.47	61.27	61.24	61.10	61.80	62.58	63.50	66.10	68.41	69.28	70.50	70.90	71.32	71.40	71.40	71.40	71.09	70.90	69.60	69.01
DISTANCE	6.975	6.997	7.000	7.012	7.021	7.025	7.030	7.036	7.050	7.055	7.062	7.068	7.075	7.079	7.082.5	7.094	7.100	7.104	7.119	7.125
STATION NO.	6+975	IP.1	7+000	7+012	7+021	7+025	7+030	7+036	7+050	7+055	7+062	7+068	7+075	7+079	IP.2	7+094	7+100	7+104	IP.3	7+125

CURVE ARRANGEMENT: IP.1 IA=13° 00′ R=100m TL=11.39m CL=22.69 SL=0.65m; IP.2 IA=47° 30′ R=30m TL=13.20m CL=24.87m SL=2.78m; IP.3 IA=50° 00′ R=20m TL=9.33m CL=17.45m SL=2.07m

DWG. 22 STRUCTURE No.17
PIPE PROTECTION & CONCRETE PAVEMENT OF ACCESS ROAD



DIMENSION

D (mm)	P (MPa)	h (mm)
250	1.0	450
300	1.0	550
	1.6	550

WASH-OUT DIMENSION

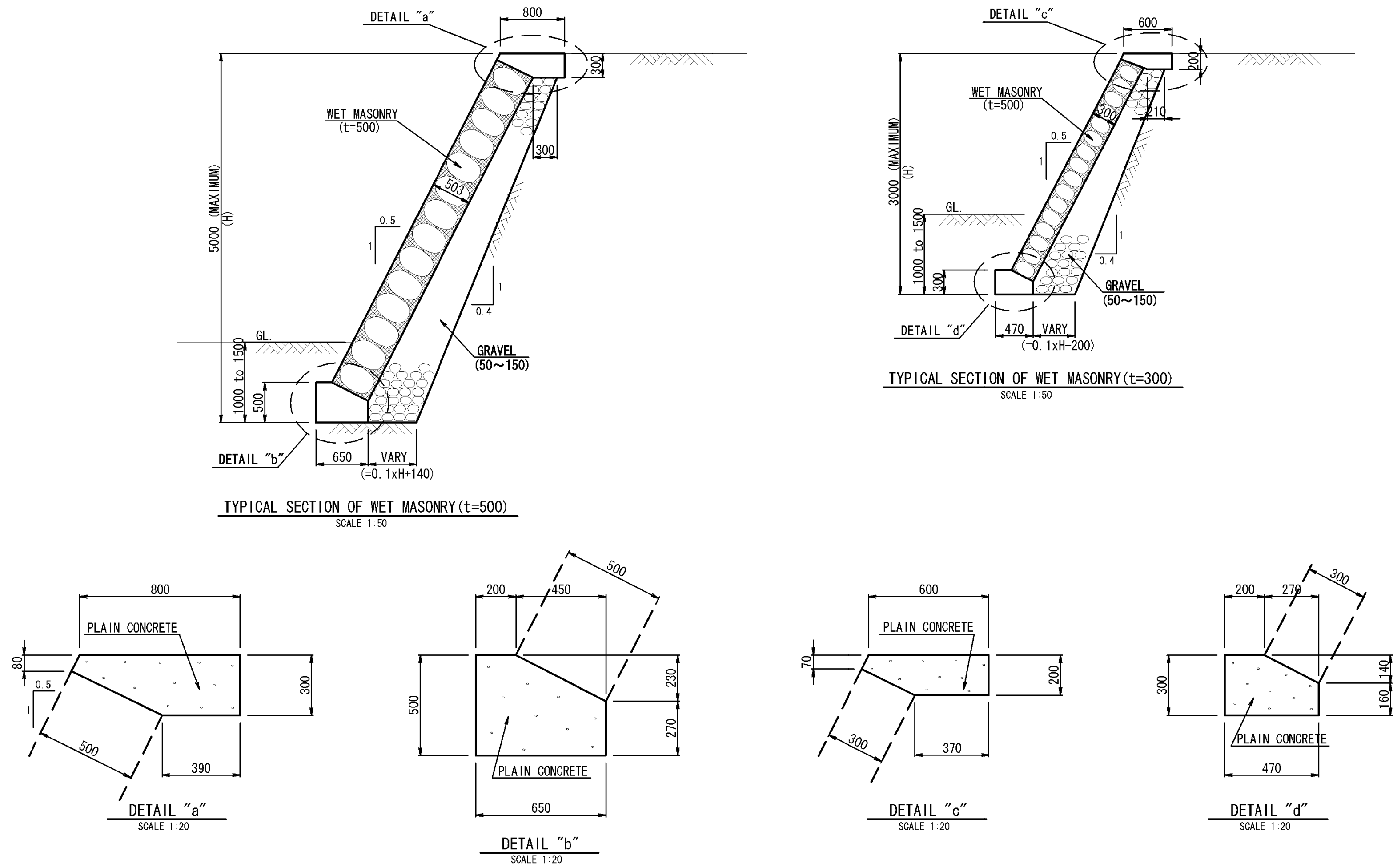
D (mm)	P (MPa)	L (mm)	h (mm)
250	1.0	275	340
300	1.0	300	340
	1.6	300	340

P:WORKING PRESSURE

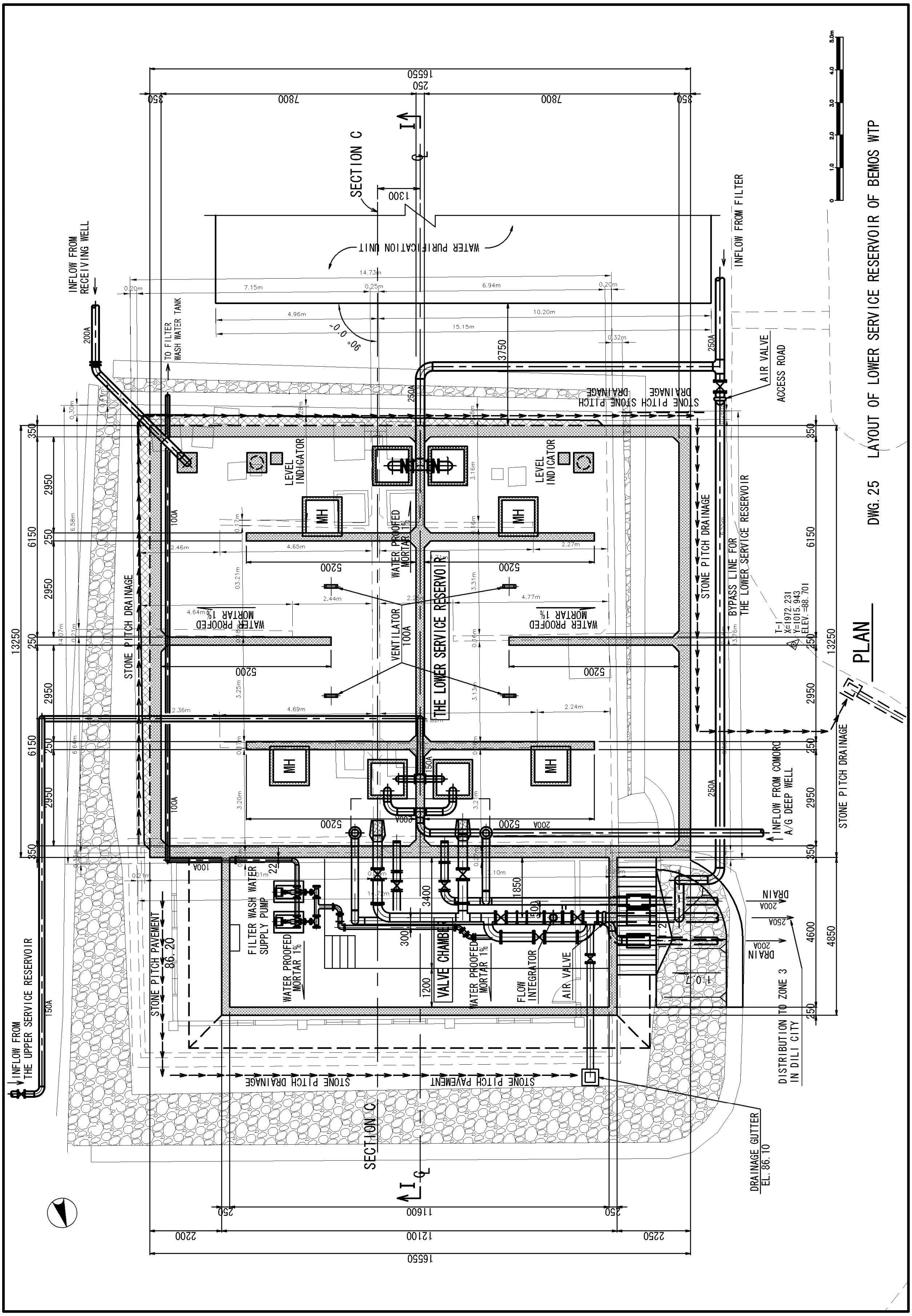
AIR VALVE DIMENSION

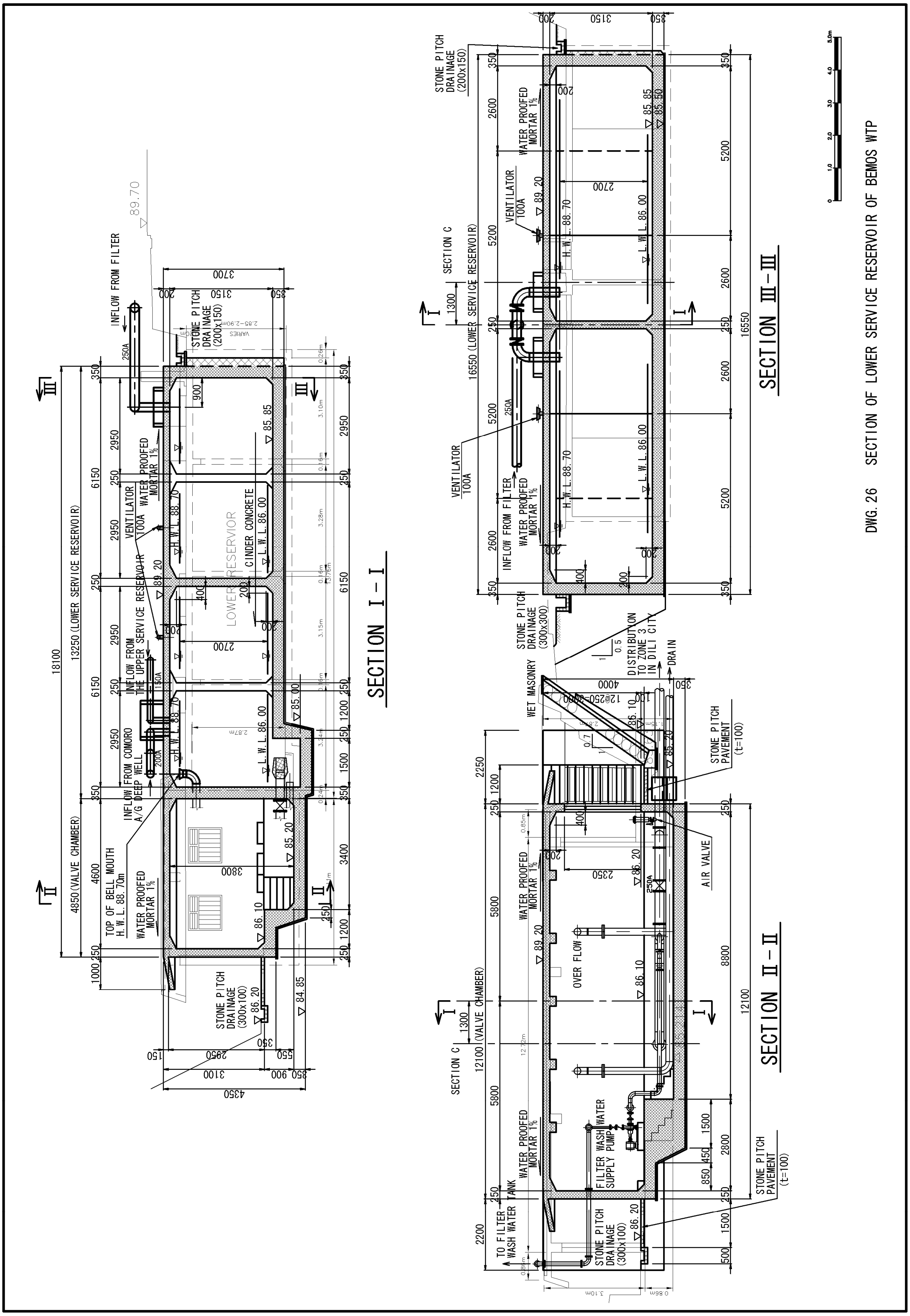
D (mm)	P (MPa)	d (mm)	h1 (mm)	h2 (mm)	h3 (mm)
250	1.0	80	550	630	≧300
300	1.0	80	600	630	≧300
	1.6	80	600	640	≧300

DWG. 23 STANDARD DETAIL OF ISOLATING VALVE, WASH-OUT & AIR VALVE CHAMBERS



DWG.24 TYPICAL SECTIONS OF WET MASONRY


DWG. 25 LAYOUT OF LOWER SERVICE RESERVOIR OF BEMOS WTP
PLAN
THE LOWER SERVICE RESERVOIR
VALVE CHAMBER
WATER PURIFICATION UNIT
SECTION C
INFLOW FROM RECEIVING WELL
TO FILTER WASH WATER TANK
INFLOW FROM FILTER
AIR VALVE
ACCESS ROAD
STONE PITCH DRAINAGE
STONE PITCH PAVEMENT
LEVEL INDICATOR
WATER PROOFED MORTAR 1%
VENTILATOR 100A
BYPASS LINE FOR THE LOWER SERVICE RESERVOIR
T-1 X=1972.231 Y=1015.943 ELEV.=88.701
INFLOW FROM COMORO A/G DEEP WELL
DRAIN
DISTRIBUTION TO ZONE 3 IN DILI CITY
DRAINAGE GUTTER EL. 86.10
FLOW INTEGRATOR
FILTER WASH WATER SUPPLY PUMP
INFLOW FROM THE UPPER SERVICE RESERVOIR
MH
16550
13250
12100
11600



DWG.26 SECTION OF LOWER SERVICE RESERVOIR OF BEMOS WTP

2-2-4 Implementation Plan

2-2-4-1 Implementation Policy

The subject grant aid project aims at rehabilitation/improvement of Bemos raw water main which has been damaged by the recent floods and a full renovation of the Lower Service Reservoir of Bemos Water Treatment Plant. Through the said rehabilitation/improvement, it is expected that those water work facilities such as intake facilities, raw water main and water treatment facilities ever constructed under the previous grant aid project may maintain the function stably to be utilized efficiently in the future.

DNSAS is the implementing agency of the project and the project is to be implemented within the framework of the grant aid system of the government of Japan. In case if the implementation of the subject project would be approved by the government of Japan after the due completion of the Basic Design study, an Exchange of Note (E/N) be got through between the governments of two countries and the project will enter into its implementation stage. Under the project implementation, a single package contract manner will be adopted.

2-2-4-1-1 Construction Policy

(1) Access Road (For construction)

The portions/sections to be rehabilitated under the project are scattered over about 7 km distance from the Bemos intake weir to the treatment plant. From the city area of Dili to the treatment plant, it is accessible by public roads but there is no road available to access further upstream area. It is necessary to transport the required equipment/materials to the working sites of rehabilitation, especially the concrete in the quantity as much as 4,700 m^3, therefore, policy is decided to provide access roads for construction on the lower river water channel and terrace.

From Bemos treatment plant to the confluence point with Bemos river, the water channel of Comoro river can be used as access road with having some leveling works. While for the Bemos river portion, river terraces on both right and left banks will be availed for access as much as possible. In case if the leveling work alone can not make it passable, then about 0.3 m of embankment will be provided with gravel pavement. For the sections where no temporary access road on the river terraces could be made, the road will be planned at the lower water channel with embankment work of 0.5-1.0 m paved by gravel. The access road for construction shall have the total width of 4.5 m (width 3.0 m + shoulder 0.75 m× 2), and be provided with sidetracks to enable facing traffic by vehicles as the sites is not of the clear passage/perspective. Further, there expected to have surface water in the river at the early stage and ending stage of dry season, though there is none during the mid-dry season, it is planned to have such river crossing works as temporary bridge and buried drainage pipes in the river crossing sections.

(2) Demolish/Disposal of Existing Structures

Demolishing of the existing structures as intake weir and service reservoir etc. shall be made by through crushing by large-size breaker in combination with the manual work by concrete breaker. Rubbish and chips of concrete produced shall be hauled and disposed at the designated place as DNSAS informed.

Concerning the intake weir, the main body of the existing weir is to be left as it is and a flushing sluice way will be installed at the inlet portion on the left bank side, and therefore, it is necessary to cause the minimum effect on the existing structure in demolishing the inlet. For this sake, a kind of static crushing material be used for causing cracks on the existing concrete so as to avoid the effect on the main body, and finally completed by the concrete breaker by manual operation.

(3) Rock Excavation and Crushing of Huge Stone and Boulder

Steep slope mountains lie in close proximity on both banks of the Bemos river, and there found a number of exposed rocks here and there with huge stones scattered in the river bed. Some of them are boulders flown down from the upper stream and it is judged that larger ones are of exposed due to the erosion/scouring on the neighboring grounds. It is also considered that there may be considerable number of huge stones in the river terraces extended on both banks.

The huge stones and boulders existing in the river terraces and riverbed will be crushed by using the large-size breaker. Crushing by using dynamite is not preferable due to the troublesome procedures for importing and stocking and also the possible negative effect on the local people in the area.

(4) Concrete Works

It is estimated that under the project as much as 4,700 m^3 of concrete will be used for various concrete structures and wet masonry etc. It is 40 m^3/day if averaged by the total period for concrete works. It is noted that the production and transportation of concrete is the key in controlling the overall construction schedule.

There is a local contractor (Australian finance) who possesses a concrete plant at the area nearby the downstream of Bemos Water Treatment Plant. Policy has been decided that concrete will be procured from this local contractor to be hauled by concrete mixer car and delivered to the construction site.

(5) Pipe Works

Under the project, there are three (3) sections where pipeline will be re-routed. For connecting with the existing pipeline, non-suspension method shall be employed as required due to the limited water supply suspension time. Moreover, removal of the existing pipes will not be executed in principle for the re-routing sections. In case of removal, however, the pipes shall be cut into pieces of re-usable length and transferred to DNSAS. Further, in the case of installing air valves, wash-out and isolating valves on the existing pipes for the purpose of improvement in O & M, non-suspension method is necessary as required due also to the limited time of allowable water suspension time.

2-2-4-1-2 Policy to Active Use of Local Contractor

During the time of Indonesian rule, most of the construction works had been undertaken by Indonesian nationals. While for those construction works under the re-construction program aided by

UN, WB, ADB and so forth after the social disorder in 1999, most of the works were carried out by the foreign contractors. Concerning Japanese contractors as many as 5 construction firms have ever participated in the construction works in Timor-Leste for road, irrigation facilities, port, water works and schools, they are Tobishima Corporation, Dai Nippon Construction, Toa Corporation, Wakachiku Corporation and Mirai Construction Co.

In Timor-Leste today, there are construction contractors in 2 manners, one solely by local nature and the other affiliated by foreign companies (Australian and Singapore). Most of the local companies are of small scale without personnel of high technical standard and construction equipment and machineries, thus in many cases tends to procure required technical staff and construction machineries after contract signing. While some of the foreign-affiliated companies are found capable enough with having a certain number of machineries, resident technicians and engineers (Foreign and local), and are doing some works as sub-contractor of the foreign companies and/or supply construction machineries and concrete.

As these companies are capable as mentioned above and considered that the quality in construction could be secured but the unit costs of the works tend to be higher as compared with the case of local contractors. Those Japanese contractors are usually performing the job through sub-contracting with plural number of the local foreign-affiliated companies depending on the kinds or works.

As is the case, under the subject project, policy is confirmed that appropriate local construction companies be positively employed depending on the kind of works in parallel with the direct work by main contractor which will be undertaken in a manner local technicians engaging the work with due guidance by the experienced technicians from the third countries.

2-2-4-1-3 Policy on Assignment of Technicians and Engineers

In Timor-Leste, those engineers and technicians who have enough knowledge and techniques on construction works are quite limited. Therefore, it is necessary to arrange the construction crew consisting with experienced technicians from the third countries like the Philippines to guide the local technicians and workers. For the form work, however, higher accuracy is to be secured and it is considered necessary to have Japanese nationals assigned to this job and guide the local technicians and workers. For the anchoring works too, it is considered necessary to assign a Japanese national technician since it is of special technique.

2-2-4-1-4 Procurement Policy

Construction materials which can be availed at the site are sand and gravel and all the others are imported ones. Price of the construction materials in Timor-Leste is comparatively higher than the neighboring countries. Also in recent years, the price escalation is considerable due to the escalation of transportation cost as caused by the price escalation of crude oil especially since the year 2006. Moreover, those construction materials as cement and reinforcing bar etc. are available in the domestic market, but the stock ready for sale is rather limited. The said materials are imported mainly from Indonesia, Australia and Singapore and direct purchase from these countries may result in more economical purchasing in the case if the quantity exceeds a certain level.

Accordingly, in case if purchasing from Japan and third countries is more advantageous in view of the quantity, delivery period and economic efficiency, materials will be procured from these countries. Further, the policy is to apply the JIS standard for the steel pipes and valves and to procure steel gates and testing equipment from Japan and the third countries since local suppliers have no experience in handling these material and equipment.

2-2-4-1-5 Policy on Construction Scheduling

The climate of the project site is of tropical monsoon type where rainy season and dry season are clearly demarcated and in the rainy season there are quite intensive rainfalls causing often floods. The project site is surrounded by steep slope mountains also and the run-off speed is very high.

Table 2-2.43 Duration of Rainy and Dry Seasons and Mean Monthly Rainfall

Season	Duration	Mean monthly	Year of Data
Rainy	Nov.-Apr.	115 mm-156 mm	1953-1999
Dry	May-Oct.	15 mm-74 mm	1953-1999

The rainy season starts at around early November and lasts till April with the mean monthly rainfall of more than 100 mm. At the mountainous area located upstream basin of Bemos river, the rain starts earlier and records more rainfall amount than Dili city area. As per the interview from the local residents, there have been some big floods even in April, ending period of the rainy season. Further, it is said that the full scale rainy season starts at around December, however, as per the information from the local contractors, they are of the opinion that the construction works at the Bemos river better be completed by the end of October.

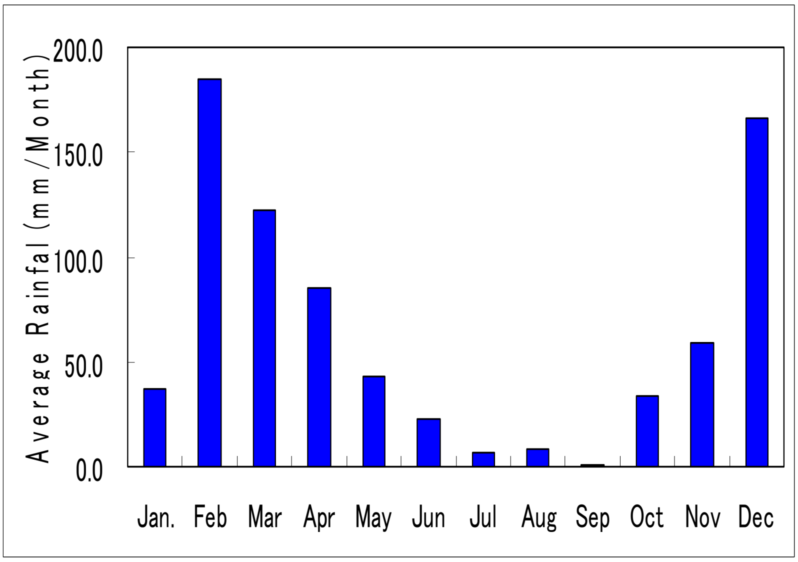


Fig. 2-2.22 Monthly Mean Rainfall at Dili in the Past 5 Years (2003-2007)

In view of the above, the policy on the construction scheduling may be confirmed that for those construction works to be undertaken in the river bed such as intake facilities shall start with the access roads at the early May and followed by the full scale construction to be completed by the end of October. While for the service reservoir, the schedule is set to start at April with minimum rainfall to be completed before December.

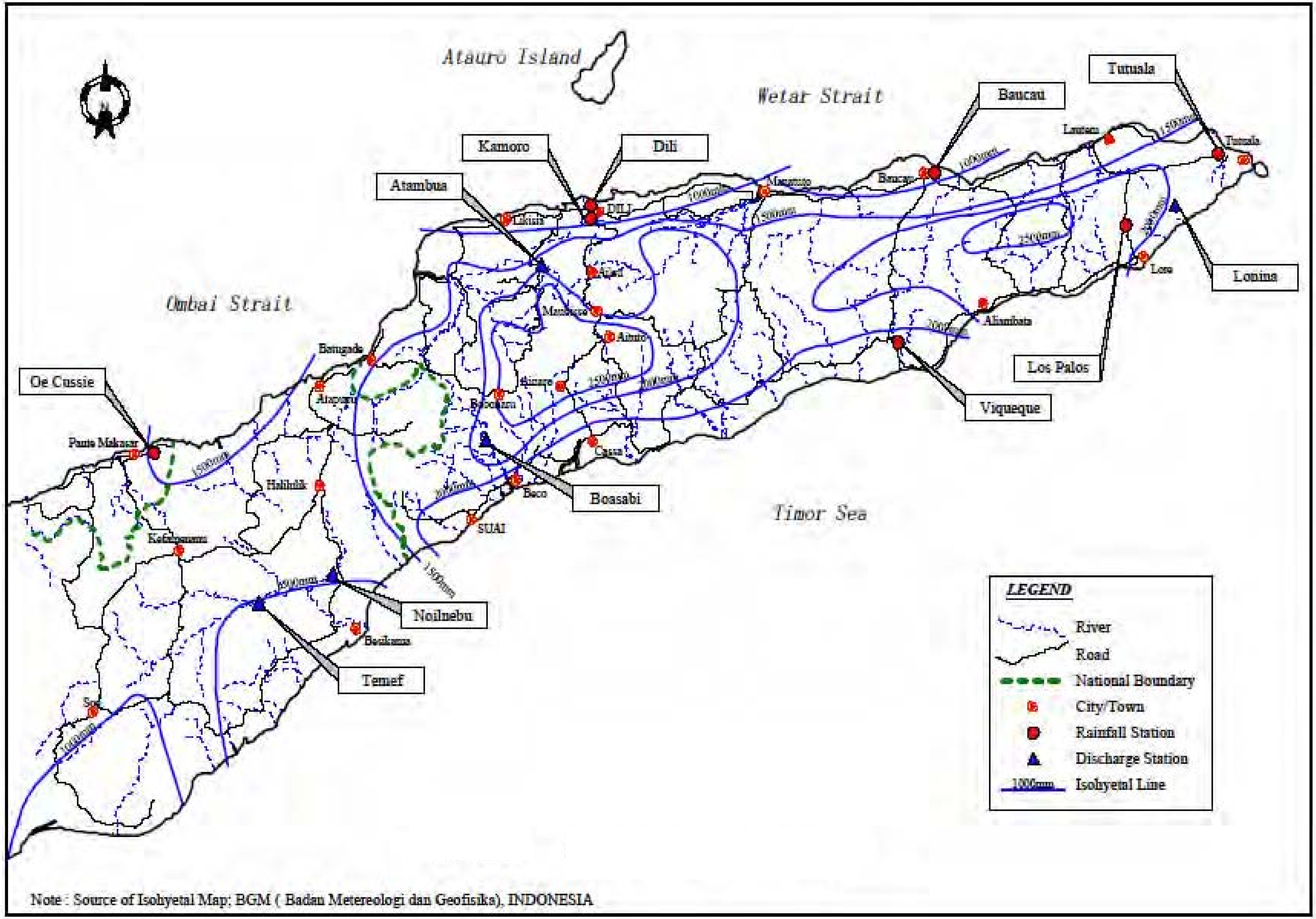


Fig. 2-2.23 Rainfall Stations and Isohyetal Line Map

2-2-4-2 Implementation Conditions

2-2-4-2-1 Bemos River Discharge

At the intake site of Bemos river, there found surface flow throughout a year, while downstream reach there, sub-surface flow may appear in the full dry season, though early parts of dry and rainy season which are in the scheduled construction period surface flows appear also. Therefore, it is planned that a coffer dam will be built at the upstream of the intake to be rehabilitated and a by-pass channel be provided. Design flood discharge is determined for planning the coffer dam and by-pass channel and taking into account the construction method and construction procedure for each related structure, construction period shall be adequately fixed.

At the intake site there is no appropriate site for excavation of by-pass channel due to the narrowed river cross section, so, water diversion by pumping is planned. Pumping capacity shall be able to divert the river discharge during July- September in which concrete placing be on-going. Concerning the run-off increase due to the rainfall in June, usually it happens only several days and during the said period there are only rock excavation work and crushing of boulder stones, construction works be suspended and the increased run-off shall flow down within the river channel. After the mid October, rainfall amount will be much increased and it is expected that the increased run-off can not be diverted by pumping as planned. As is the case, it is necessary to shorten the construction period as much as possible so that all the related works could be completed by mid-October when river run-off will remain still at low level.

It is planned that all the works related with the intake facilities be completed by the mid-October, however, in case if some works may delay in actual, it may be necessary to provide a multiple-stage diversion facilities by embankment due to the fact that the scheduled work is the river bed protection (Crossing type concrete block) at the downstream of the intake.

Table 2-2.44 Records of Rainfall at Dili (2003-2007)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Max. Monthly (mm/month)	56.7	518.3	224.6	133.4	155.5	72.2	15.9	23.7	3.6	93.8	161.0	245.0
Ave. Monthly (mm/month)	37.3	184.9	122.0	85.6	42.7	22.5	7.1	8.6	0.7	34.0	58.8	166.6
Min. Monthly (mm/month)	12.5	25.4	35.5	30.4	0.4	3.0	0.0	0.0	0.0	2.2	0.0	90.6
Max. Daily (mm/day)	15.1	126.7	113.4	87.0	35.0	39.4	12.5	12.4	3.2	60.2	69.4	76.2

2-2-4-2-2 Limitation in Water Supply Suspension Time

Through the consultation meeting with the DNSAS, it was confirmed that water supply suspension is impossible during 6:00AM-10:00AM and 3:00PM-9:00PM each day taking into account the peak time of water demand and also water supply suspension shall be limited only for three (3) days in a week. Therefore, possible suspension time in a day is fixed for 5 hours of 10:00AM-3:00PM and it is necessary to adopt construction/installation methods which enable to finish within the fixed time available for re-routing of pipeline and installation isolated valves and etc. If it is necessary, non-suspension method shall be considered too.

2-2-4-2-3 Installation of Temporary Raw Water Supply Facilities at the Intake

In order to secure raw water supply during the rehabilitation/improvement of raw water main, raw water be taken at the upstream of the existing intake facilities and conveyed downstream through the connection with the existing raw water main.

Table 2-2.45 Quantity of Raw Water

Structure No	Quantity of raw water
Structure No. 1 Bemos Intake weir	102 liter/sec

2-2-4-2-4 Installation of Temporary Water Supply Facilities for Service Reservoir

For the rehabilitation/improvement of the Lower Service Reservoir, it is planned that water be distributed to the users of Dili city through the Upper Service Reservoir. This requires water supply from the treatment plant to the Upper Service Reservoir. The Upper Service Reservoir is situated at higher level than the treatment plant and temporary pumping facilities are required for this purpose.

Table 2-2.46 Quantity of Water for Distribution

Structure No.	Quantity of water for distribution
Structure No. 19: Service reservoir	26 liter/sec

2-2-4-2-5 Removing of the Existing Lower Service Reservoir

The existing Lower Service Reservoir is of excavated type with having treatment facilities on the south side, and on the east side the Lower Service Reservoir is located near the foundation works of wet masonry revetment to protect the slope under the Upper Service Reservoir. As is the case, it is planned that the two (2) side walls as mentioned shall remain as they are during the construction. In order to protect the side walls from collapsing due to earth pressure, some measures like anchoring may be needed.

2-2-4-2-6 Collecting of Aggregate and Stone Materials

As per the “Environmental Guideline” as effective in Timor-Leste, it is specified as regulations that prohibit stock-yard installation in the river course, prohibit change of river course which may cause river bank erosion, requires clear marking of gravel collecting site and limit collecting gravels in the river and so on. Also it is necessary to have a thorough presentation of the material collecting plan for the local administrations and communities concerned. As the case may be, when the contractors will proceed to aggregate and stone material collecting under the project, they have to obtain necessary permissions for the material collecting from the authorities concerned.

2-2-4-2-7 Compensation for Standing Trees and Land Acquisition

It is necessary to make compensation for the standing trees and lands required for the project facilities such as grit chamber and access roads for construction. The government of Timor-Leste is requested to take necessary actions to complete required compensation procedures based on the Basic Design as well as Detailed Design prior to the commencement of construction works under the project.

Access roads for construction are planned basically to pass either river low water channel or river bank terraces, but there are possibilities that the local residents may claim that they own the lands in river terraces. At the river bank terrace on the left bank of the intake weir site, there existed some banana plantations and fish ponds, thereby requiring to remove them temporarily for providing the access roads. This requires DNSAS to carry out proper orientation/explanation to the local communities concerned, and those facilities temporarily removed for the subject project construction purpose shall be restored as a responsibility of the construction contractors.

2-2-4-2-8 Concrete Placing under the High Temperature Condition

Under the project, it is expected to have some concrete placing under the condition of high temperature. In case of concrete placing where mean daily temperature may exceed 25℃, the placing shall be performed in conformity with the technical specification of "hot weather concrete". With this concern, due attention shall be paid by the contractors in practicing proper slump control during concrete mixing and also the curing by water so as not to cause cracking caused by shrinkage and temperature fluctuation. Further, the hauling distance from ready-mixed concrete plant to the placing site via, access road in river course is quite long and it is necessary to manage the time needed for mixing and hauling and placing to be within 1.5 hours in case of temperature exceeding 25℃ and 2.0 hours in case of lower than 25℃.

2-2-4-2-9 Temporary Stock-yard

Construction sites are scattered over the river terraces, courses and channels in the mountain areas, and there are possibilities of robbery of equipment and materials if stocked at the sites. Therefore, it is preferable to have a stock-yard provided at the suburb of Dili city and be transported to the construction sites on daily basis. In case if it is necessary to store construction machineries and materials, some counter-measures for prevention of possible robbery shall be worked out.

2-2-4-2-10 Technicians and Labors for Construction Works

Jobless ratio in the urban area of Timor-Leste is quite high and accordingly the labor market is in the oversupply state. However, since the time of Indonesian rule, those categories of job which requires higher knowledge and techniques have been monopolized by Indonesian nationals and the present situation is that there are very few engineers and technicians locally available.

Based on the past experience in implementing grant aid projects in Timor Leste, it is a customary practice to procure/employ required labors from the communities located nearby the construction sites and many of the local residents are in the jobless state, then, a kind of short term rotation manner is necessary to be adopted. Being different from each locality, but long term employment can not be expected, anyhow (Only 2 weeks rotation), then the productivity of the labor seems to be low.

<Regulations in accordance with the Labor Code, Employment conditions>

The Labor Code consisting of 47 provisions and called "Regulation No.2002/5 on the

Establishment of a Labor Code for East Timor" was stipulated and in force since May 1, 2002. The Labor Code regulates the employment conditions as follows and a form of employment agreement is shown. The form was prepared based on the long term employment and considered the conditions therein are of employee's preference. The form is used to be applied for the employment of labors on project basis.

- Need for informing the discharging in advance (10 days before in case of 3-6 months employment, 15 days before in 6-12 months and 30 days in longer than 1 year case)
- No stipulation about the discharge allowance but pay is customarily practiced.
- Paid leave: 1 day for 1 month working and in case of non-use, to be paid/compensation
- Working hours: 8 hours/day (Maximum 12 hours including over time), 44 hours/week
- Over time: 150% for week days and 200% for holidays

2-2-4-2-11 Transportation and Custom Clearance

It can be said that the handling/unloading capacity of Dili port is quite limited. Accordingly if there are a number of cargo ships in the port, it will take many days for unloading and for custom clearance. While there expected major parts of equipment/materials needed for project construction are to be procured from Japan and other third countries, it is necessary to make a sound construction scheduling with due time allowances for transportation and custom clearance.

2-2-4-3 Scope of Works

The subject grant aid project will be implemented and operated with the demarcation of the obligations as shown below.

2-2-4-3-1 Obligations of the Government of Japan

Table 2-2.47 Work Items to be Rehabilitated under GOJ grant

Work items	Length	Rehabilitation / Improvement manner
1. Intake weir	-	• Construction of sand sluiceway • Improvement of apron and river bed protection • Repair of crest and abutment • Temporary intake facility during construction
2. Inlet and Grit chamber	17 m.	• Improvement of inlet • A part of pipeline be changed to connecting canal • Construction of grit chamber • Construction of Sand Sluice canal
4. 0+495 ~ 0+742 River crossing No.1	50 m.	• Concrete reinforcement on existing pipeline protection • Construction of groundsill and river bed protection at lower stream reach • Scouring Protection Revetment on both banks • Construction of wash-out
5. 0+584 ~ 0+742 Right bank river terrace, crossing with tributary and existing wing of retaining wall	200 m.	• Change of pipeline route and tributary crossing by aqueduct • Construction of Flow Path at the tributary crossing • Construction of Wash-out

Work items	Length	Rehabilitation / Improvement manner
6. 0+787 ~ 0+876 Existing upstream concrete retaining wall	80 m.	• In between the retaining wall and upright rise around the pipe be re-filled with sand and gravel and covered by gabion • Retaining wall heightening (partially) • A part of pipeline be shifted
7. 0+876 ~ 0+947 Right bank river terrace	100 m.	• Revetment on river terrace
8. 1+142 ~ 1+220 River crossing No.2	80 m.	• Concrete reinforcement on concrete river bed protection • Construction of groundsill and river bed protection at lower stream reach • Scouring protection revetment on both banks • Construction of wash-out
10-1 1P34 / 1P36 (1+420 ~ 1+530) Existing downstream concrete retaining wall	59 m.	• In between the retaining wall and upright rise around the pipe be re-filled with sand and gravel • Heightening of retaining wall (partially) • Foot protection works for foundation of retaining wall
10-2 1P42 (1+938) Left bank terrace of Bemos river	50 m.	• Protection of existing pipeline by revetment and re-filling by sand and gravel
10-3 2+094 ~ 2+200 Left bank terrace of Bemos river (Pipeline hanging in the air)	100 m.	• Route change and embedding the pipe in river bed • Encasement by concrete • River bed protection
11. 2+365 ~ 2+570 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
17. 7+000 ~ 7+100 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
18. Isolating valve, wash-outs	-	• Allocate as required for easier O&M
19. Bemos Water Treatment Plant The Lower service reservoir & valve chamber	-	• Renovate the facilities to have the same capacity and function with the existing ones • Temporary water convey facility from purification unit to Upper Service Reservoir during construction

2-2-4-3-2 Obligations of the Government of Timor-Leste

In addition to the general matters to be born by the government of Timor-Leste in implementing the grant aid project, some additional work items to be undertaken by the government of Timor-Leste are noted as the followings.

- Pump operation cost for supply of water from treatment plant to the Upper Service Reservoir during the construction of the Lower Service Reservoir
- Land acquisition necessary for facilities rehabilitation: Grit chamber
- Installation of entrance gate and fence regarding rehabilitation: Intake, Grit chamber
- Payment of commission and A/P handling charges to Japanese bank based on Banking Arrangement
- Exemption of custom duty on the imported equipment/materials at the port of unloading and

assistance in custom clearance

- To bear the cost of custom duty on goods and services
- Proper use and O & M on the facilities rehabilitated under the subject grant aid project
- Advanced information to the local residents on the suspension of water supply
- Counter-measures for the damages on the facilities caused by disaster and floods occurred prior to the commencement of construction works under the grant aid, and supplementary measures for protection, if necessary

2-2-4-4 Consultant Supervision

2-2-4-4-1 Organizational Set-up for Construction Supervision and Matters of Concern

In performing the detailed design and construction supervision for the subject project, attention shall be paid on the following matters and due organizational set-up is necessary towards successful accomplishment.

- It is important to fully grasp the content and particulars/circumstances of the basic design study.
- It is necessary to fully understand the frame and system of the grant aid project by the government of Japan.
- To grasp the content of E/N exchanged by and between two governments
- Necessary to grasp always trend and moves of other aid agencies concerned and policy of DNSAS
- Re-confirm the obligations of the government of Timor-Leste towards the project implementation as requested during the basic design study
- Re-confirm the obligations of the government of Timor-Leste concerning the duty exemption and assistances in custom clearance at the time of importing equipment and materials under the project through due consultation with DNSAS so as not to cause undue delay in the construction progress.

After the E/N be exchanged by and between the government of two countries, the government of Timor-Leste will sign a consulting service agreement with a Japanese consulting firm. The consulting service agreement shall be divided into two phases, one for the detailed design and the other for the construction supervision.

2-2-4-4-2 Detailed Design

Scope of the consulting services under the detailed design phase shall include the followings.

1) Field survey as needed for designing and detailed design (including stability analysis of structures as retaining wall, stability analysis of anchor and variety of examination works)
2) Preparation of tender documents based on the detailed design
3) Estimation of construction cost based on the detailed design (Review on the cost estimate under the basic design) and fixing of ceiling price
4) Assistances in PQ evaluation, attendance in tender, tender evaluation and assistances in contract negotiation.

It is planned also that the following designated engineers, specialist as well as staff will be assigned as a consultant’s team to perform the consulting services as mentioned above.

Project Manager (Chief engineer)
Design Engineer for river structures (Intake)
Design Engineer for river structures (Revetment and river crossing)
Design Engineer for water works facilities (Pipeline)
Design Engineer for water works facilities (Service reservoir)
Civil Design Engineer (Structure/Quantity estimation)
Electrical Design Engineer
Tender Document Specialist
Construction Planning Engineer/Cost estimate (Incl. Supervising of surveying)
Draftman

2-2-4-4-3 Construction Supervision

Scope of the consulting services under the construction supervision phase shall include the followings.

1) Consultation meeting among parties concerned prior to the commencement of construction works
2) Processing for the approval of construction drawings
3) Supervising works for control of progress, quality and safety in construction works
4) Factory inspection on the equipment/materials before shipping, survey on quantities completed, various tests, quality tests and completion inspection
5) Preparation of reports during the construction period and reporting to client and JICA
6) Issuance of completion certificate for construction works and payment certificate

Concerning the organizational set-up for the construction supervision, the Project Manager will assume the overall responsibility of construction supervision with having a Resident Supervisor assigned at the project site throughout the construction period. Further, the Electrical Engineer will be assigned for the spot-supervising on the electrical restoration works for the service reservoir and an inspector will be assigned to attend the completion inspection at the time of termination of construction works. Under the construction supervision plan for the subject project, a Civil Engineer from the third country (Philippines) is to be assigned as the assistant to the Resident Supervisor.

2-2-4-5 Quality Control Plan

For the control of quality and completed quantity, it is planned to apply the following quality control methods. Inspection/test results shall be recorded for each item of works and such specification, structure and functions as specified in the contract shall be secured It is expected that concrete is to be procured from the local contractors in Dili and in case of mixing in place quality inspection is necessary to be undertaken for each section of concrete placing depending on the importance of the structures.

Table 2-2.48 Contents of Quality Control Plan

Works	Items to be controlled	Method	Frequency
Embankment	Compaction degree	In-site density test	For major parts
Excavation bed	Soil condition Width/height	Visual Measurement of dimension/height	For major parts For major parts
Wet Masonry	Stone, Mortar	Stone size, Mixed proportion between sand and cement	Every 400m^2
Concrete	Aggregate Cement Concrete	Grain-size analysis test Physical test/Chemical test Slump, air, water/cement ratio and compressive strength test (7days, 28days) Quality Certificate by plant for Ready-mixed concrete	Once Once Every class placement once a day And also each 150 m^3
Reinforcement bar	Strength Assembling condition	Tensile strength test Rebar assembling inspection	Once Every parts
Form, Support	Setting Location Strength	Fixing location & method Design & calculation report	Every parts As required
Anchor	Mortar	Compressive strength test Flow-table test	Each day
Structure as built	As built dimension	Measuring dimension	For major parts
Water proofing works	Quality of material Condition of coating Existence of leakage	Check of quality certificate Visual Water impound test	Every certificate Every service reservoir - ditto -
Mechanical equipment	Installation accuracy Function	Installed position measurement Loaded operation test	For all equipment For all equipment on operation test
Pipe material Piping works	Strength, dimension Appearance, dimension Torque Welding Existence of leakage	Check of mill test report Visual, size check Torque wrench Color check Water pressure test	Each approval Every delivery, Every installation As required 5% of welded length Every new alignment

In undertaking the quality control as specified above, the following standards/guidelines are to be applied and during the course of detailed design a consultation meeting with DNSAAS shall be held so that the selected standards be reflected in the tender documents.

JIS - Japanese Industrial Standards
JWWA - Japanese Water Works Association
SNI - Standard National Indonesia
ACI - American Concrete Institute
ASTM - American Society for Testing and Materials
BS - British Standard
ISO - International Organization for Standardization

Further, concerning the standards for construction supervision, the Resident Supervisor assigned shall prepare them referring to the followings and apply the same with keeping them at the site office.

- Standards for civil work construction supervision, ministry of Land, Infrastructure, Transportation and Tourism, Government of Japan

- Guideline for standard construction supervision under Grant Aid project, JICA

2-2-4-6 Plan for Procurement of Construction Materials

2-2-4-6-1 Procurement of Materials

In Timor-Leste, almost all the construction materials are imported ones except sand and rock/stone materials. Due to this there are several liner-ships are on services and several construction materials suppliers are operating the business with imported materials from Indonesia, Singapore and Australia. With this situation, construction materials in general are available in Timor-Leste except some special ones.

In price-wise, however, materials available in the country are comparatively higher than the neighboring countries and also due to the limited quantity of materials handled by the whole-sellers in Dili, direct purchase from the neighboring countries may be advantageous in case of big quantity of materials to be procured.

In view of the above-mentioned situation, whether the materials be purchased from the local dealer or by direct purchase from the neighboring countries shall be judged taking into account the transportation cost, delivery period and the price itself. The following table shows possible sources of materials to be procured.

Table 2-2.49 Sources of Materials Procurement

Items	Demarcation			Remarks
	Timor -Leste	Japan	Third country	
1) Concrete	○			
2) Sand	○			
3) Fine aggregate & coarse aggregate	○			
4) Cement	○		○	It is preferable to procure from abroad directly in case of heavy use, though imported ones are in circulation.
5) Reinforcing bar	○		○	
6) Stone	○			
7) Wood / timbers	○		○	It is preferable to procure from abroad directly in case of heavy use, though imported ones are in circulation.
8) Plywood	○	○	○	
9) Steel scaffold & scaffold board		○		
10) Material for form		○		
11) Water stop, joint filler		○		
12) Coating material for waterproof		○		
13) Steel pipe		○		
14) Valves		○		
15) Gate		○		
16) Fuel & lubricant	○			

Note: Third countries assumed are Indonesia, Australia and Singapore.

(1) Aggregate/Stone Materials

Under this project, it is planned to procure the concrete from the local contractor who has a concrete plant in Dili and there expected no need for purchasing aggregate materials in large quantity. While the project requires procuring much stone materials for uses in wet masonry revetment and wet stone pitching works. Aggregate and stone materials are available by collecting from the Comoro river and others and materials dealers purchase the aggregate and stone materials from the local residents. Therefore, such aggregate and stone materials are to be purchased from the local dealers as said.

(2) Cement

Cement is all imported and mainly it is of made in Indonesia generally. In case if a lot of cement is required for construction purpose, cement is either purchased from the domestic whole-seller or local contractor or procured directly from the exporter in Indonesia. The cement price at the time of field survey (1 month period) has been escalated two times due to the global basis price escalation for all the commodities.

There is a report that Indonesian-made cement can not secure 35N/square mm, required strength for the high strength concrete, and due attention shall be paid in case of using the Indonesian-made cement for the high strength concrete.

(3) Concrete

At the downstream area of Bemos Water Treatment Plant, there is a local contractor (Australian finance) who has a concrete plant, and many of the constructors purchase the concrete from this local contractor. Through testing no problem is found in its quality and for the project cement is planned to be procured from the same local contractor. Further, in case if it is necessary to use partially cast-in place concrete, such concrete shall be prepared by using aggregate, cement and water satisfying the specifications and applying the mixing ratio as confirmed satisfactorily in the mixing test.

Table 2-2.50 Standard for Concretes

Kind of concrete	Compressive strength
Plain concrete	$18N/mm^2$
Reinforced concrete	$21N/mm^2$
High strength concrete	$35N/mm^2$
Pavement concrete	$21N/mm^2$

(4) Reinforcing Bar

All the reinforcing bar being availed in the country is imported one. The most are from Indonesia and followed by Australia. The price is even higher than the market price in Japan due to the inclusion of high transportation cost. Under the project, it is estimated that as much as 40 tons of reinforcing bar is required and policy of procurement is to purchase the same made in the third countries which secures the quality standard and available in the local market.

(5) Steel Pipes and Valves

For the existing raw water main from Bemos intake to the treatment plant, steel pipes of JIS standard are used. Under the subject project the section to be rerouted is only 400 m in length and therefore it is planned to be procured from Japan. Isolating valves and air valves too, source of the procurement is planned to be Japan.

(6) Gates (Intake and Sluiceway)

In case of procurement from Japan, there are sufficient numbers of gate manufacturers and system has been established for safe delivery and certified quality standard While if procured from countries in South-east Asian countries, manufacturing may be possible but design may not be complete and preparation of shop drawing is separately required. It requires also dispatching of qualified engineer for quality and schedule control at the manufacture's factory. As is the case and considering the size of the gate rather small scale and the quantity is 4 only, it is planned that the gate facilities for the project will be procured from Japan too for higher reliability in quality and delivery period.

(7) Materials for Temporary Works

Such materials for form-work as form-tie, wooden cone and separator are not available in Timor-Leste and planned to be procured from Japan. Also the materials for temporary works as steel-scaffolding and steel supports are not commonly available in the market in Timor-Leste and planned to be procured from Japan. While, such materials used for temporary works as colgate pipes and PVC shall be locally procured.

2-2-4-6-2 Procurement of Construction Machineries

Under the urgent re-construction program implemented with the UN aid, there were high demands for various construction machineries and several local contractors affiliated by foreign contractors own various types of common construction machineries such as backhoe, bulldozer, dump truck and truck crane. As is the case, these machineries are available in Timor-Leste on rental basis.

Table 2-2.51 Sources of Machineries Procurement

Items		Demarcation			Remarks
		Timor -Leste	Japan	Third country	
1)	Backhoe	○			$0.6m^3$ class
2)	Bulldozer	○			15t class and 3t class
3)	Motor grader	○			3.1m class
4)	Dump truck	○			10t、4t
5)	Truck with crane	○			4t (2.9t crane)
6)	Truck crane	○			10-11t、25t、35t
7)	Tire roller	○			8-20t class
8)	Vibration roller	○			0.8-1.1t class
9)	Concrete mixer	○			$0.2\text{-}0.3m^3$
10)	Concrete mixer truck	○			$5m^3$
11)	Generator	○			2kVA, 5kVA, 45kVA
12)	Pump	○			8inch、2inch、6inch
13)	Welding machine	○			Engine 300A
14)	Tamper	○			60～100kg
15)	Boring machine		○	○	

Note: Third countries assumed are Indonesia, Australia and Singapore.

It is noted, however, that the rental cost of these machineries remains at very high level similar to the previous case, since these machineries were urgently imported from neighboring countries by local contractors without having any rental market and most of the rental contracts were concluded with very high rate at the time of UN’s urgent re-construction program implementation.

In case of construction machineries to be used on long term basis, there are possibilities that the cost of machineries procured from the third countries or Japan can be lower than the rental cost in Timor-Leste, and therefore, procurement of construction machineries shall be determined through examining the assignment period of the machineries and other relevant factors. The following table shows the possible sources of the procurement of major construction machineries.

2-2-4-7 Implementation Schedule

Project implementation schedule is planned with the following period where dry season factor is the key in accomplishing efficiently work progress for such river structures as intake facilities and also the service reservoir of Bemos Water Treatment Plant.

Detailed design : Approx. 7.5 months (Including tendering)
Construction : Approx. 10.5 months (Contract signing to the completion)

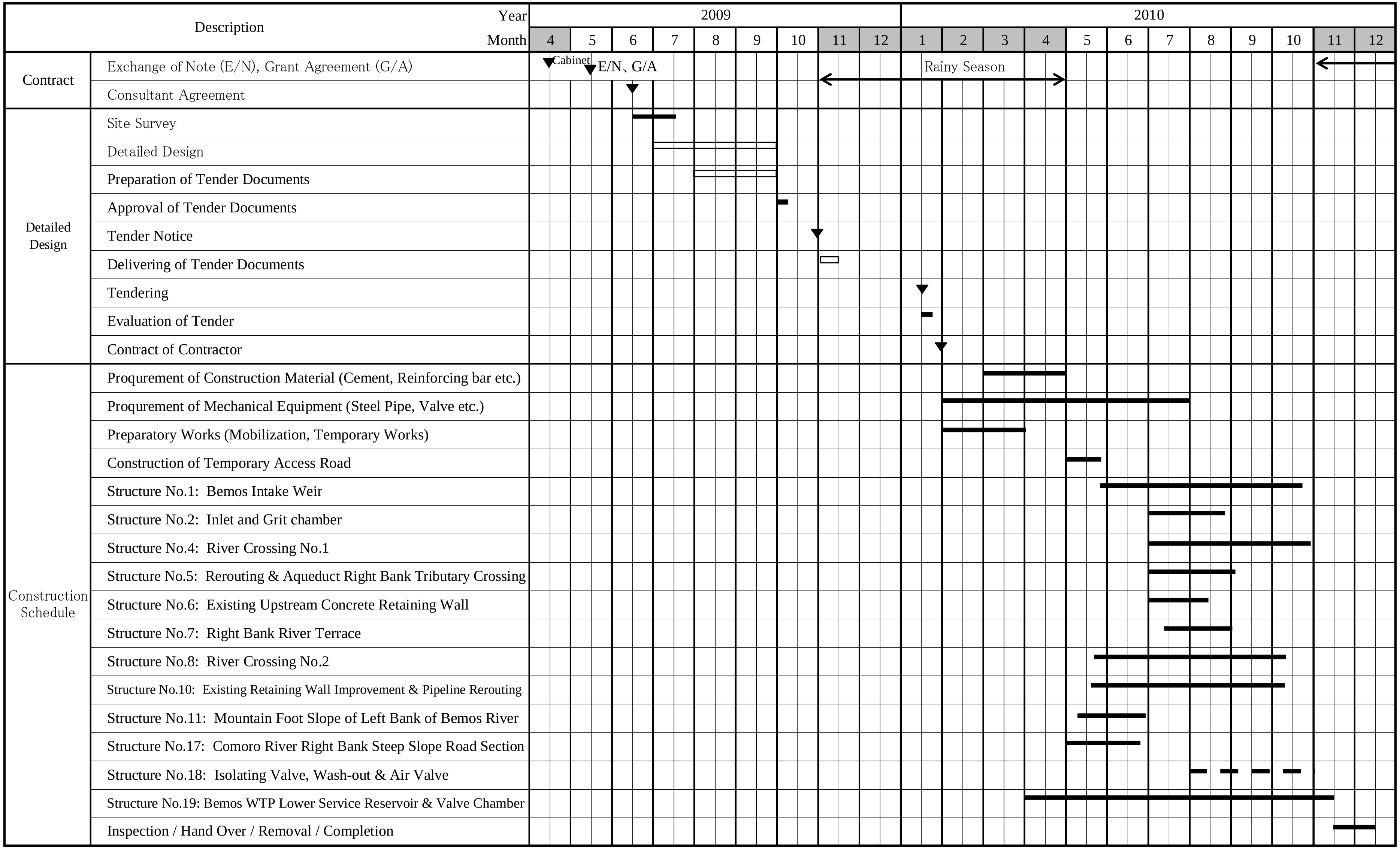


Fig. 2-2.24 Project Implementation Schedule