NATIONAL DIRECTORATE FOR
IRRIGATION AND WATER MANAGEMENT
MINISTRY OF AGRICULTURE AND FISHERIES
THE DEMOCRATIC REPUBLIC OF TIMOR-LESTE

THE PREPARATORY SURVEY REPORT ON THE PROJECT FOR REHABILITATION AND IMPROVEMENT OF BULUTO IRRIGATION SCHEME IN THE DEMOCRATIC REPUBLIC OF TIMOR-LESTE

September 2013

Japan International Cooperation Agency

NTC International Co., Ltd.

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Preface

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to NTC International Co., Ltd.

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

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

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

September, 2013

Kumashiro Teruyoshi
Director General
Rural Development Department
Japan International Cooperation Agency

Summary

1. Background and outline of the project

The Democratic Republic of Timor-Leste (RDTL) has an area of 14,900 km^2 and the total population is 1,180,000 persons (WB: 2011). Among the total population, seventy percent (70%) are living in rural area and are engaged in the agricultural sector. Rice production value occupies about forty percent (40%) of total non-petroleum industry, and about eighty percent (80%) of the export value of non-petroleum products.

The main crops in RDTL are rice, maize and cassava. However, mostly extensive farming is practiced. The crop yield is about 2 ton/ha in 2010 which is extremely low in comparison with the other South-East Asian countries (Indonesia in 2010: 5.01 ton/ha, Vietnam in 2010: 4.98 ton/ha). The self-sufficiency rate of rice production is around 40~50%. The improvement of rice production is necessary for food security and economic development in RDTL.

The proposed Buluto scheme that was selected out of the nine prioritized projects is located at the physical boundary of the Manatuto and Baucau Districts. The proposed scheme is located close to the capital city of Dili, and the National road 01 which connects Dili and Baucau which ensures the good market access of rice to be produced in the scheme. Thus, such situation contributes to develop an incentive of rice production for the farmers. Since the exiting intake structures were constructed with the riverbed materials and fascine, the intake capacity is unstable due to destruction of the intake facilities and deposition of the river sediments in the canal. Therefore, rehabilitation of the existing irrigation facilities with durable structure will improve the water supply condition effectively.

2. Contents of the Project

The contents of the Project requested by the Government of RDTL were discussed by both the sides during site survey period and the necessity of rehabilitation was confirmed based on the findings of the site survey. The schedule of the site survey is as follows.

First Survey	:	from 29th October, 2012 to 19th December, 2012 (52 days)
Second Survey	:	from 29th June, 2013 to 10th July, 2013 (12days)
Supplementary Survey	:	from 21th March, 2013 to 5th April, 2003 (17 days)

The contents of facilities are described below.

Contents of Facilities

Name of Facilities	Outline of Facilities
Intake Facility	
Fixed Weir	Concrete Structure, Weir Length: 200m, Weir Height: 2m, Scouring Sluice Gate: 2.5m(B)×2.1m(H)×2 spans (Sluice Gate)
Intake	Intake of Water Quantity: 2.4m^3/sec, Intake Gate: 1.5m(B)×0.8m(H)×4Spans (Sluice Gate)
Sediment Trap	Structure: Concrete, Double Line Canal, 50m(L)×8m(B: 4m×2 lines), Capacity of Sediment Trap: 440m^3, Scouring Sluice Gate: 2.0m(B)×1.2m(H)×2 spans (Sluice Gate)
Headrace	Length: 236m (Including Sediment Trap and Transition Canal) Intake Discharge Control Gate: 2.0m (B)×0.75m(H)×2 Spans (Sluice Gate)
Guide Wall (River Bank Protection)	Semi Gravity Retaining wall (Both Side of Intake): H=9.6 to 8.1m (at Weir Axis)
Flood protection Dike	Earthern Dike (Intake Right Bank Upstream): H=7 to 8m (Slope Protection by Concrete Frame)
Gate Control Room	5m×12m=60m^2
Left Bank Headrace	Intake at the Left Bank (Concrete Pipe φ800mm) Control of the Discharge by the Sluice Gate (300mm×300mm) Concrete Pile to Maintain the Inside of Concrete Pipe
Irrigation Canal	
The Number of Canal	Main Canal: 1Route, Secondary Canal: 16Routes
Length	Main Canal: 12.3km, Secondary Canal Total: 15.4km
Canal Type	Main Canal: Masonry and Plain Concrete Base Secondary Canal: Earth Canal
O & M Road	
Improved Section	Only 1.3km of O&M Road from intake to distribution facility will be improved. The national road will be used except for the 1.3km of O&M Road.
Road Type	Gravel Paving: 3.5m(B)
Drainage Canal (Upstream : No,1, Downstream : No.2)	
Gabion	Upstream: 7Sections, Downstream: 5Sections
Gabion Cross section length	Upstream: 7Sections×5m (B/site) =35m(Total Length), Downstream: 5Sections ×10m (B/site) =50m (Total Length)
River bank Protection (Downstream potion of Vemasse river)	
Structure Type	Gabion (Bottom: 2Lines, 3Steps), Height: 3m
WUA Office	
Floor Area	87$m^{2,}$ Toilet (Separated Building): 17.5 m^2
Structure Type	One-storied Building, Concrete Pier, Block Wall, Roof of Galvanizing Plate
Demonstration Farm	
Demonstration Farm	0.6ha (0.3ha×2 sites: Laleia Side 1, Vemasse Side 1) Demonstration for the Improvement of Farm Management
Soft Component	
Formation and Strengthening of WUA	Formation of Water Users' Association (WUA) Strengthening of WUA for the Operation and Maintenance of Facilities

(1) Upper Level Plan and Purpose of the Project

The proposed Project for Rehabilitation and Improvement of Buluto Irrigation Scheme aims at achieving the following 3 targets to increase the agricultural production by 2020 in accordance with the Strategic Development Plan of SDP 2011-2030 which is the Overall Goal of agriculture development of the Government of Timor Leste:

1) Increase in irrigated paddy field area from 50,000ha to 70,000ha,
2) Increase in the paddy yield from 1.43 ton/ha to 2.02 ton/ha (2030) and
3) Decrease in the storage loss at the farm level from 20% to 5% (2030)

The Irrigation Development Plan was presented to achieve the overall goals, and the Government proposed 9 irrigation projects including the Project in Buluto. Therefore, the implementation of the Project is in line with the development policy of the Government. Three projects among remaining projects are in progress, which are implemented by the local fund in Calaulun, Beikala and Raivere.

The objective of the proposed Project is to enhance the livelihood level of the beneficiary farmers and to contribute to increase the self sufficiency of the country by improvement of the Buluto Irrigation Scheme and increasing the rice production. The effect of the production increase of the Project is considerable, since the Project is a large scale irrigation project in Timor-Leste. By means of completion of the headworks by the Project, the rice production is increased by stable supply of irrigation water in the rainy season and expansion of the second cropping of rice in the dry season, when the market price of rice is high.

In order to accomplish the overall goal and objectives of the Project, the stable intake and supply of irrigation water are inevitable considering the climate change (extraordinary flood, etc.). Therefore, the new development and improvement of the irrigation facilities and improvement of operation and maintenance by soft components are prerequisite for input, activities and output of the Project.

(2) Basic Concept

In formulating the Project, the position, relevance, impacts and technical and economic feasibility of the Japanese Grant Aid towards the implementation of this Project are to be verified, and thereby the essential and optimum design of the planned facilities is provided for obtaining proper outputs of the Project.

The design of the facilities consists of: 1) design of headworks with various gates to intake stable water from Laleia river, 2) design of the main canal and secondary canals to convey and distribute the irrigation water to the paddy field of 780 ha, and 3) design of other facilities such as improvement of 2 drainage canals to drain local rain water, revetment along the Vemasse river to protect the main canal, and meeting facility for WUA.

An intake gate was constructed at the proposed site for new headworks at the right bank of the Laleia river, but it was collapsed by floods and has not been used. The old main canal, which connected with collapsed intake, still provides some irrigation water from temporary intake at just downstream

only in the rainy season. However, the period and amount of irrigation water supply is limited due to high elevation of the canal bed and small cross section of the canal caused by sedimentation.

The Scope of Works for recovering the functions of the irrigation system, which was requested by the Government of Timor-Leste has been revised and specified clearly. There is additional description for the facilities of "sediment trap and gate operation house for head works related facilities", and "a meeting facility of Water Users' Association (WUA), revetment and demonstration farm for the canal related facilities".

(3) Policies on Natural Environmental Conditions

1) Design Flood Discharge

The discharge observation data are available for only 10 years for the Laleia river during the time of Indonesia with insufficient reliability. The flood discharge was, therefore, estimated by the flood mark survey of the local people in the vicinity and the interview survey with the results of the river profile and cross section survey during the field survey. The calculation results reveal that the design flood discharge was estimated at 1,500 m^3/s for 100-years probability.

2) Design Drought Discharge

The drought discharge in the dry season was estimated with 5-years probability of occurrence in order to estimate the irrigated area in the fry season and rainy season.

According to the estimation above, in the beginning of December when the land preparation starts, sufficient discharge was confirmed in the river to irrigate entire 780 ha of crop cultivation in the rainy season, while a half of the entire area (390 ha) is possible to be irrigated in the dry season.

3) Geology of the Proposed Area of Intake Facilities

According to the results of the field investigation by the use of an excavator, the sediment deposit in the right and left banks with a depth of 2 to 3 meters from the ground surface consists of silty sand (finer grain is more) and the layer deeper than 2 to 3 meters consists of sand and gravel mixed with boulders. The foundation ground of the river bed with a depth of 2 meters from the ground surface consists of sand (finer grain is less) and the layer at about 3 meters depth consists of sand and gravel mixed with boulders.

Judging from the results, the river bed is expected to have sufficient strength considering the depth of the foundation of structures. On the other hand, the coefficient of permeability of the foundation ground with a depth of 3 to 4 meters from the riverbed surface was measured as high as 2×10^{-3} m/s which requires attention to control the permeability of the foundation ground as a design policy.

(4) Conditions of Farm Management and Irrigation Facilities

The main purpose of the Project is improvement and upgrading of the function of the Buluto Irrigation Scheme through construction of new intake facilities and improvement and extension of the irrigation canals, and enhancement of livelihood by improvement of farm management environment through stable intake of irrigation water. The Project will contribute to the national target for the food self-sufficiency by an increase in rice production by stable irrigation water supply in the rainy season and the production in half of the Project area in the dry season.

In order to assist an increase in rice production, the guidance for farm management by the extension officers is expected to be executed. The Integrated Crop Management (ICM) has been introduced to the area of 30% of the Project area, and the rice production has increased at 20%. The proposed Project aims to increase the productivity further through expansion of the area covered by the improved rice cultivation method, i.e. ICM. In addition, the soft component of the Project is planned to be conducted to transfer techniques related to the effective operation and maintenance of the irrigation water management facilities.

(5) Policies on Socio-economic Conditions

The implementation of the improvement of the Buluto Irrigation Scheme is deemed to bring positive impact to the local economy through the production increase and associated enhancement of the livelihood of the beneficiaries. The proposed Project is expected to distribute equal benefit to most of the farmers, because large land owner is not observed in the area.

The Project does not aim at significant changes in the present life style and custom of the farmers, but aims at increasing the rice production and livelihood enhancement by introduction of the modern irrigation system and improvement of the existing facilities for the beneficiaries of the Buluto system area which still practice traditional rice cultivation with unstable and low production. It is judged from the view point of gender that the incremental labor force is not distributed only to the women, because the farming in family or community is commonly done by both men and women.

(6) Policies on the Construction and Procurement

There are 5 to 6 medium scaled local contractors managed by Timorese and some construction firms established by foreign capitals in Timor-Leste. As to local constructors, most of them are small scale, and they are engaged in revetment works, roads, river improvement, building, etc. mainly in and around Dili. They own construction machineries and equipment to some extent and are possible to be engaged in works such as earth work, concrete work, etc. which does not require high level techniques. Therefore, it is judged to be possible for these contractors to be engaged in the implementation of the proposed Project as a sub-contractor under adequate quality control carried out by the Japanese contractor as a prime contractor.

Currently, several projects are under planning and implementation, which include improvement plan of National Road No.1 by the Japanese Yen credit and 3 irrigation projects financed by the

Government. Since most of the construction materials and equipment are imported and procured by the international contract, there is an escalation of the construction cost and shortage of number of labors and technicians. In respect to construction equipment, concrete plant, etc. as required, they shall be imported from Japan or other advanced countries in the vicinity.

(7) Policies toward Management, Operation and Maintenance

The soft component is provided for realizing these capacity improvement targets as a supporting activity, and assisting to obtain required knowledge and techniques and to sustain operation and maintenance. Key points of operation and maintenance are enumerated below:

- In order to carry out the effective operation and maintenance of the irrigation facilities to be constructed and improved by the Project, the Project assists the National Directorate of Irrigation Water Management for the establishment of WUA.
- Aiming at sustainable use of irrigation facilities to be constructed by the Project, the Project will conduct training to the members of the WUA for studying and understanding of the operation and maintenance techniques.
- Pertinent method of water management such as operation of gates should be learned by the WUA members so that the facilities can be used effectively by the farmers.

(8) Policies on the Establishment of the Grade of the Planned Facilities

The facilities of the Buluto Irrigation Scheme shall be designed by adopting the following parameters based on natural and environmental conditions and the scale of the target area:

- Design water intake: 2.40 m^3/s (maximum intake discharge)
- Design flood discharge: 1,500 m^3/s (flood discharge with 100-years probability)

Since the planned flood discharge of 1,500 m^3/s is higher value, it is required to design structures with sufficient stability against enormous flood energy considering the sustainable structure.

In regard to the facilities to be constructed outside the river such as canal, the same policy of upgrading and rehabilitation works is applied considering that the possibility of proper maintenance by the local population in Timor-Leste can lead to long-term operation of functions of the facilities.

3. Project Implementation Plan and Project Cost

The process of the construction work of this Project is as follow.

- Detailed design: about 3.0 months
- Bidding/ contract period: about 2.5 months
- Construction work: about 20.0 months (the period includes starting from contract with the contractor to the completion)

4. Project Evaluation

(1) Relevance

The goals of agriculture sector stated in the SDP (2011 to 2030) are improvement of food security, reduction of rural poverty, support to process of shift from subsistence agriculture to marketing agriculture about agricultural crops and livestock, fisheries, environmental persistence enhancement and natural resources protection. The related points with the project are as follows.

- 2011 to 2015: Increase in the rice production from 37,500 tons to 61,262 tons
- 2016 to 2020: Exceed the demand over the food supply
  Increase in Irrigable paddy field from 50,000 ha to 70,000ha
- 2021 to 2030: Decrease in on-farm rice storage loss from 20% to 5%

These contents attributes for increase in the rice production. In this context, this irrigation project harmonizes with the agricultural development policy.

GOJ has cooperated RDTL under the notion as “Establishing the foundation for the economic growth from the instauration”. Thus the important subjects are “establishing the foundation for the economic growth”, “agricultural and rural development” and “capacity building of public sector and government”. In the field of “agricultural and rural development”, GOJ puts priority of cooperation on improvement of productivity and food security and promotion of agribusiness for promotion of employment, poverty reduction and food security. As the Project harmonizes with this policy, the relevance of the Project is judged as high.

(2) Effectiveness

The expected impacts of the implementation of the project are as follows.

- Quantitative Impacts

The main objective of the Project is to increase the rice production. Hence, the target for rice production in 3 years after completion of the Project is set as follows.

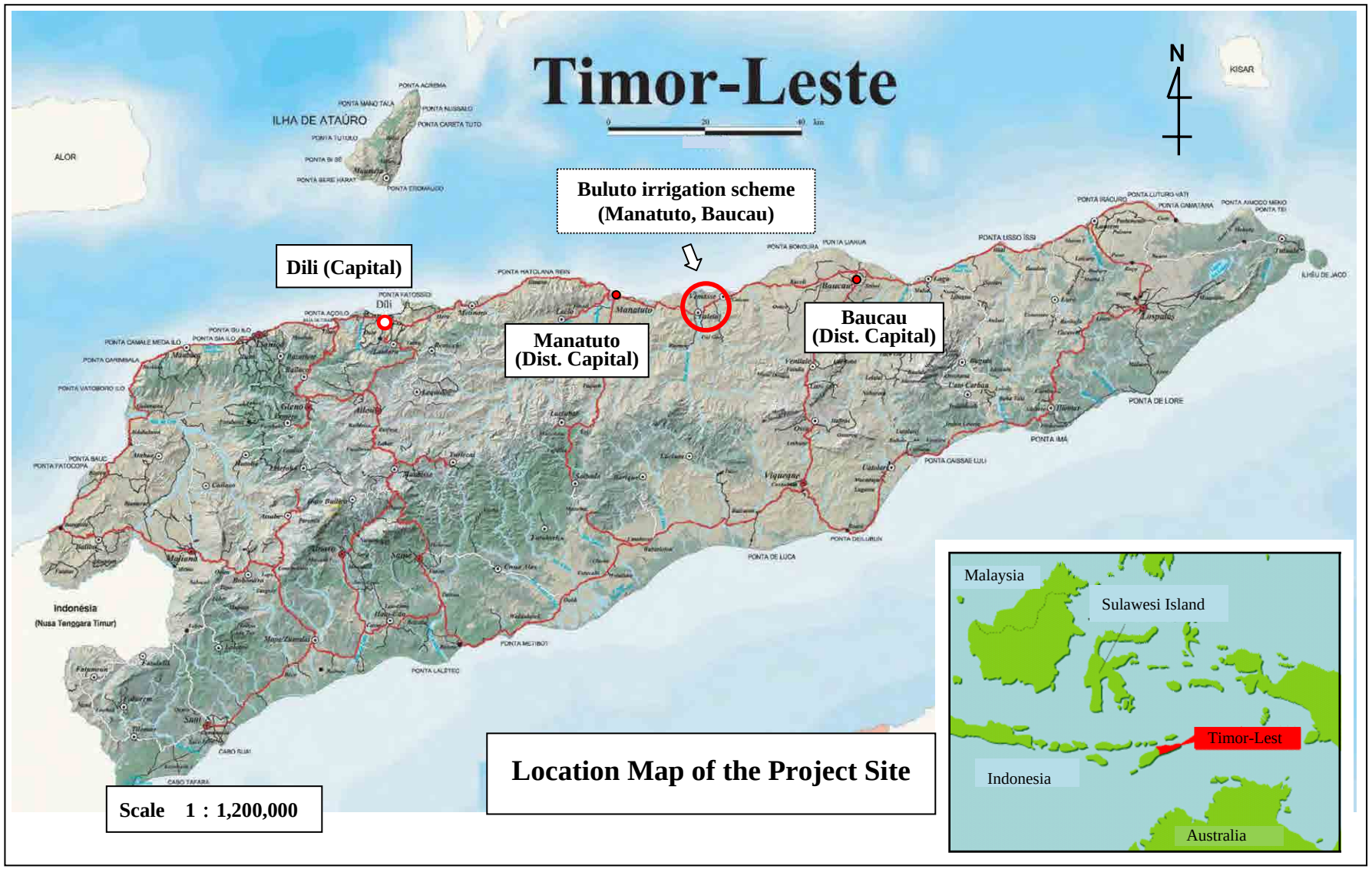
Indicator for the Quantitative Impact

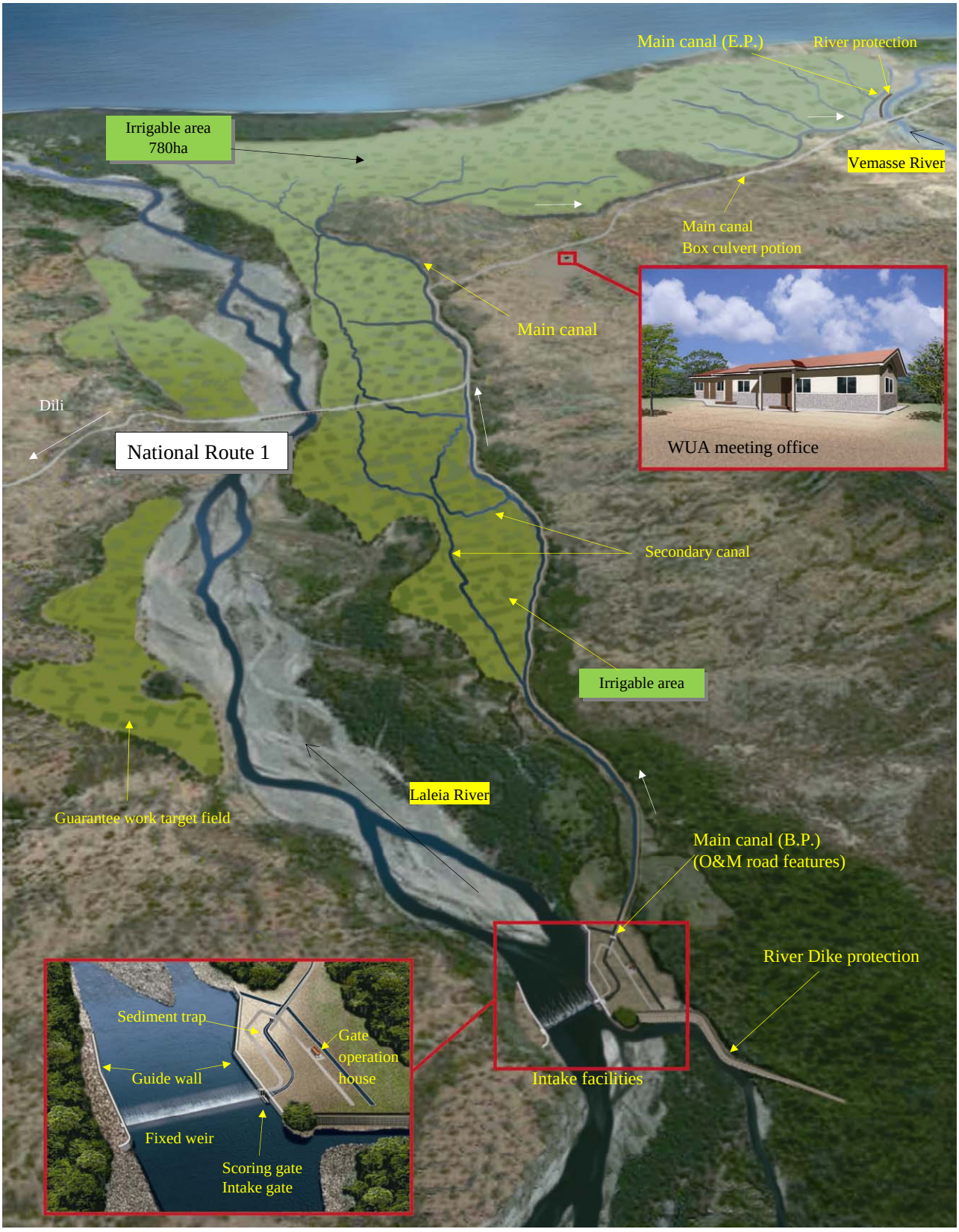
Items	Descriptions	Baseline (2012)	Target (2018) 3 years after completion
Yield of Rice (ton/ha)	Throughout the Year	1.87	2.50
Planted Area (ha)	Rainy Season	473	540
	Dry Season	61	270
Irrigable Area (ha)	Rainy Season	331	540
	Dry Season	61	270

- Qualitative Impacts
  - Livelihood of farmers can be improved, as the production of rice is increased.
  - The productivity of rice will be improved, as the labor work of for repairing the earth canal is reduced by the lining of the main canal, and thereby increased labor force can be used for cultivation.
  - Trafficability and accessibility of vehicles and the agricultural machinery such as tractors will be improved, as maintenance road along with to the canals is constructed.

Contents

Location Map





Perspective

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Abbreviations

Abbreviations	Name
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
A/P	Authorization to pay
ASCE	American Society of Civil Engineers
AusAID	Australian Agency for International Development
B/A	Banking Arrangement
CLN	Centro Logistic National
C/P	Counterpart Part
DAC	Development Assistance Committee
DNAF	Director Nacional de Administração & Finanças (National Directorate for Administration and Finance)
DNPP	Director Nacional de Política e Planeamento (National Directorate for Policies and Planning)
DNPIAC	Director Nacional das Plantas Industriais e Agro-Comércio (National Directorate for Industrial Crops & Agribusiness)
DNPSE	Director Nacional de Pesquisas e Serviços Espaecializados (National Directorate for Research & Specialist Services)
DNAH	Director Nacional de Agriculutura e Horticultura (National Directorate for Agriculture & Horticulture)
DNF	Director Nacional das Florestas (National Directorate for Forestry)
DNIGUA/ (NDIWM)	Director Nacional de Irrigação e Gestão da Utilização de Água (National Directorate for Irrigation and Water Use Management)
EC	European Commission
EDF	European Development Fund
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
E/N	Exchange of Note
FAO	United Nations Food and Agricultural Organization
F/S	Feasibility Study
G/A	Grant Agreement
GDP	Gross Domestic Product
GFATM	The Global Fund to Fight AIDS, Tuberculosis and Malaria
GIZ	Deutsche Gesell-schaft fur Inter-natio-nale Zusam-men-arbeit (German Society for International Cooperation)
IBA	Impact and Benefits Agreement
ICM	Integrated Crop Management
IEE	Initial Environmental Examination
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
MAF	Ministry of Agriculture and Fisheries
MCIE	Ministry of Commerce, Industry and Environment
MOF	Ministry of Finance

Abbreviations	Name
NBSAP	National Biodiversity Strategy and Action Plan
NDE	National Directorate of Environment
NGO	Non Governmental Organization
OECD	Organization for Economic Cooperation and Development
PKF	Peacekeeping Force
PKO	United Nations Peacekeeping Operations
RDTL	Republica Democratia de Timor-Leste
SDP	Strategic Development Plan 2011-2030
SoL	Seeds of Life
SSE	Secretary of State for Environment
TOR	Terms of Reference
UNDP	United Nations Development Program
UNFPA	United Nations Population Fund
UNMIT	United Nations Integrated Mission in Timor-Leste
UNPOL	United Nations Police
WB	World Bank
WUA	Water Users' Association

Units

1US$=80.38 Yen (Rate at the estimation, December 2012)

1ha=10,000m^2

1kg=1,000g

1km=1,000m

CHAPTER 1 BACK GROUND OF THE PROJECT

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1-1 Introduction

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The Government of RDTL requested the Grant Aid Project to GOJ based on the results of Pre-feasibility study in the Preparatory Survey on Irrigated Rice Cultivation in Timor-Leste conducted by JICA in 2011.

The preparatory survey has aimed to prepare the outline designs, to decide the contents and appropriate range of the Project and to confirm relevance and effectiveness of the Project.

1-2 Outline of the Preparatory Survey

The purpose of the Project is that the self-sufficiency rate of rice in RDTL will be increased through improvement of the production faculties. The rehabilitation of Buluto irrigation systems is necessary for increasing the food production. The requested contents were discussed by both the sides during site survey period and the necessity of rehabilitation was confirmed based on the findings of the site survey. The schedule of the site survey is as follows.

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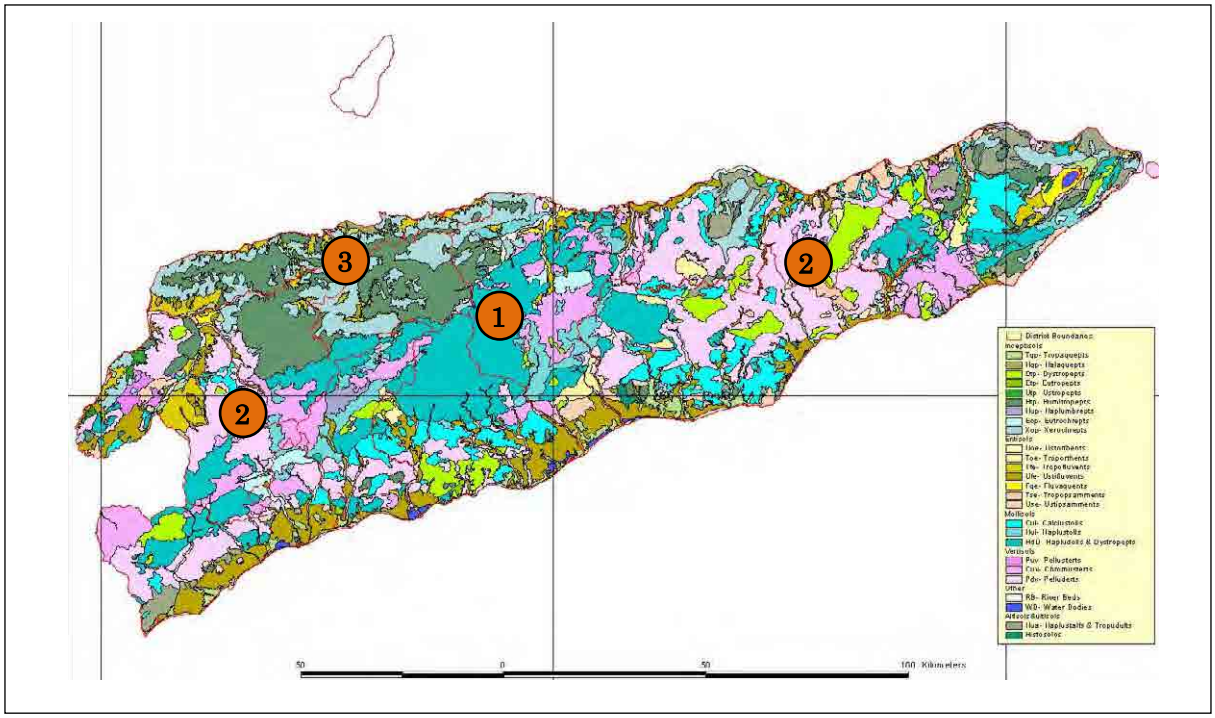
Soft Component	
Formation and Strengthening of WUA	Formation of Water Users' Association (WUA) Strengthening of WUA for the Operation and Maintenance of Facilities

1-3 Natural Conditions

1-3-1 Topography and Geological Conditions

(1) Sediment Discharge

The quantity of discharged sediments, originated from the central mountain range and discharged into the Timor Sea, seems to be considerable, and this phenomenon is confirmed by the existence of vast flood plains located along the Timor Sea. On the other hand, in the north-western area of the country, it is estimated that sediment discharge is rather small, because black soils and clayey soils are less owing to their origins (base rocks). In addition, the major rivers in this area do not influence much on the surface soils located at the downstream side. As characteristics of this area, there is little floodplain in comparison with other areas. It is estimated that the area has rather stable natural environment since soils, which are not influenced by natural disturbance (river inundation) are widely distributed.



① Black soil areas: Quantity of discharged sediments is high.
② Clayey soil areas originated from mudstone: Quantity of discharged sediments is high.
③ Areas originated from metamorphic rock: Quantity of discharged sediments is low.

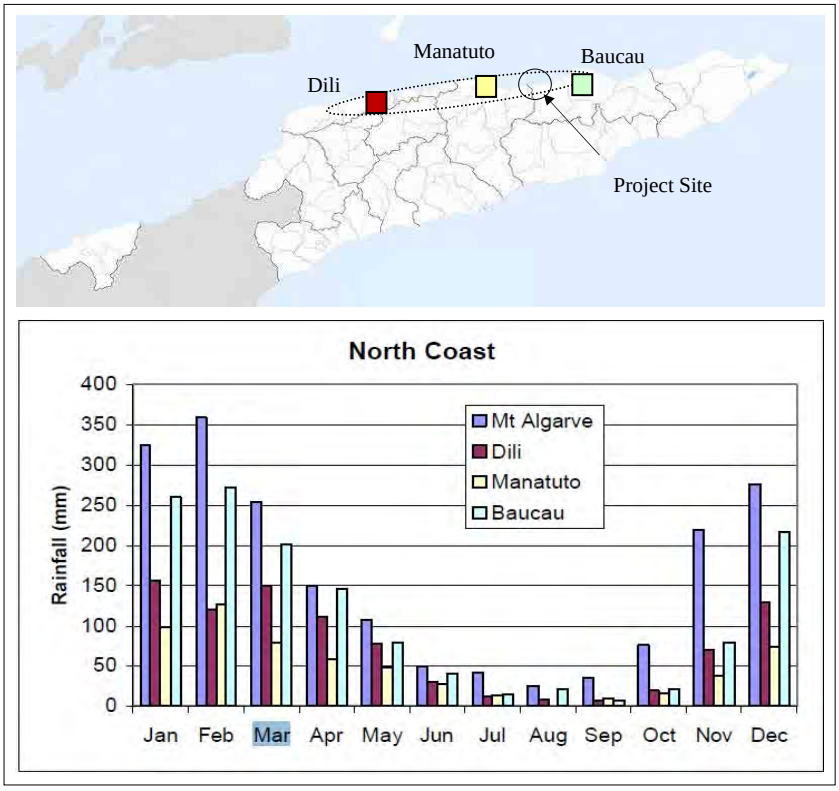
Figure 1-1 Soil Map

Based on the above, sediment discharges in the country have a high relationship with the organic matters and clayey soils distributed around the central mountain ranges, and it is estimated that the sediment discharges are high except for the north-western area. Therefore, the countermeasures through investigation and study of sedimentation are necessary for the design of irrigation facilities.

1-3-2 Rainfall

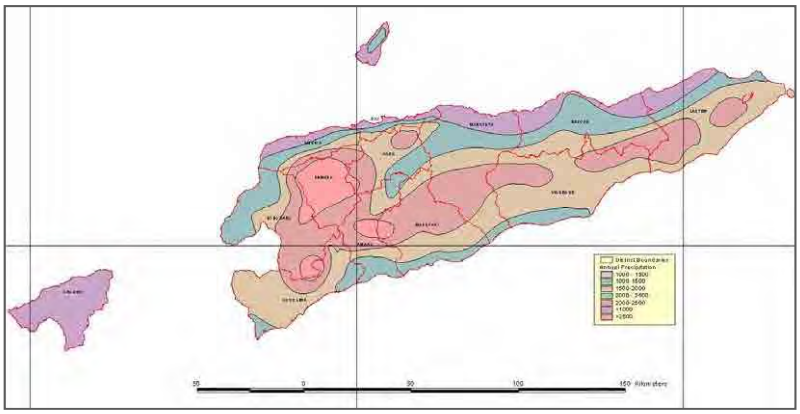
(1) Rainfall

The amount and pattern of monthly precipitation around the northern area is described in Figure 1-2. The project site is located in the northern area, where the precipitation is low in general. The annual rainfall of Dili is 891mm, and it is marked as low in comparison with the other locations. (Rainfall data source: Assessment of Water Availability and Water Demand in Timor-Leste at River Basin Level, Timor-Leste Integrated Water Resource Management Project (IWRM), 2004, Observation: 1952-1972) Isohyetal map is described in Figure 1-3. The amount of precipitation of northern area located from Dili to Baucau is high during January and February. The difference and variation in amount and pattern of precipitation is affected by the monsoon.



Source : Assessment of Water Availability and Water Demand in Timor-Leste at River Basin Level, 2004, ADB

Figure 1-2 Amount and Pattern of Monthly Precipitation around the Northern Area



Legend

District Boundaries
Annual Precipitation
1000 - 1500
1000-1500
1500-2000
2000 - 2500
2000-2500
<1000
>2500

Source : East Timor Agricultural and Land Use GIS, AGWEST International

Figure 1-3 Isohyetal Map

1-3-3 Discharge Condition of Laleia River and Vemasse River

(1) River discharge

The discharge data are available from 1952 to 1972, although there is no data in the recent years. The monthly average flood discharge data around the intake site is shown in Table 1-2. Normally the discharge data of 5 years return period is utilized for the formulation of irrigation plan.

The highest flood discharge of Laleia River was recorded in March and the average rate was 11.7m^3/sec. On the other hand, the lowest was recorded in November, and the discharge rate was 2.0m^3/sec. During rice cropping in dry season, land preparation is held in October. In October, the river discharge rate was 4.3m^3/sec. Therefore, enough river discharge is available for rice cultivation during dry season, because the required irrigation discharge in October is estimated as 3.1m^3/sec (The discharge is expressed in 5 years probability).

The flood discharge affects the weir construction work seriously. For weir construction, the excavation is required until 4m deep from the riverbed. Therefore, the schedule of the weir construction is restricted from October to December, when the river discharge is the smallest.

Table 1-2 Monthly Average Flood Discharge at Intake Site

(Unit: m^3/sec)

River	(km^2)	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Lareia	533	AVE.	8.03	14.18	15.16	15.01	15.38	12.85	9.86	6.42	6.10	3.66	3.40	5.97	9.67
		5-year probability	1.98	5.49	7.92	9.10	7.21	5.83	4.41	3.14	2.31	1.64	1.47	1.94	4.37
Vemasse	210	AVE.	1.27	2.95	4.78	5.13	3.81	2.82	1.94	1.42	1.08	0.78	0.73	1.05	2.31
		5-year probability	0.67	0.98	1.75	3.01	2.35	1.93	1.38	1.05	0.85	0.63	0.54	0.56	1.31

Source: Assessment of Water Availability and Water Demand in Timor-Leste at River Basin Level, Timor-Leste Integrated Water Resource Management Project (IWRM), 2004, Observation: 1952-1972

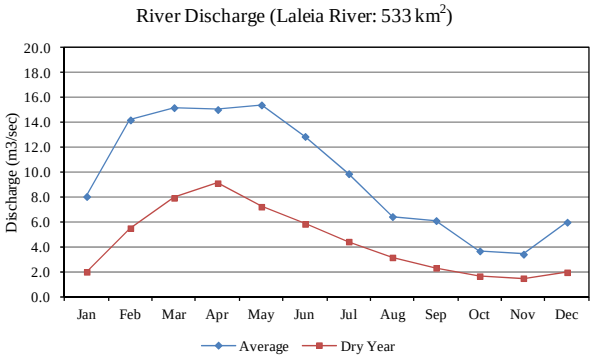


Figure 1-4 Laleia River Discharge

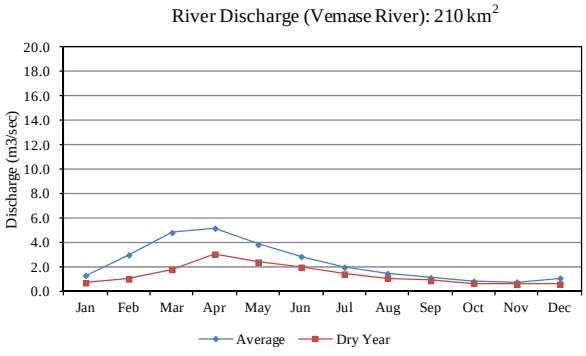


Figure 1-5 Vemasse River Discharge

1-3-4 Survey of Natural Conditions

(1) Survey Contents

The survey of national conditions was conducted around the project site. The survey contents are as follows.

Table 1-3 Contents of the Survey

Contents	Details	Units	Survey Objects
Geological Survey	Trench excavation around intake 8 sites Extraction the soils at each site	49m/8sites	To confirm the soil capability to be installed intake facilities
Topographic Survey	1. Longitudinal and Cross Section 1) River Survey 2) River Dike Protection 3) Main Canal Route Survey 4) Secondary Canal Route Survey 5) Proposed Intake Site	 1) 18,400m 2) 2,200m 3) 8,800m 4) 8,400m 5) 9,500m	To collect topographic conditions to conduct outline design
	2. Installation of guide pegs along the irrigation canal and drainage canal	33,900m	To confirm land boundary
River Survey	Survey of Laleia River 1) Discharge 2) Water Level	2012.11 to 2013.6 1) 2times/month 2) 2times/day	To determine the intake water level and intake water amount.

(2) Soil Survey

1) Test Trench Examination

The test trench examination was conducted at 12 sites of the proposed intake site. The surface soil is composed of silt up to 2 to 3m. Sandy layers are observed from 3m below the riverbed.

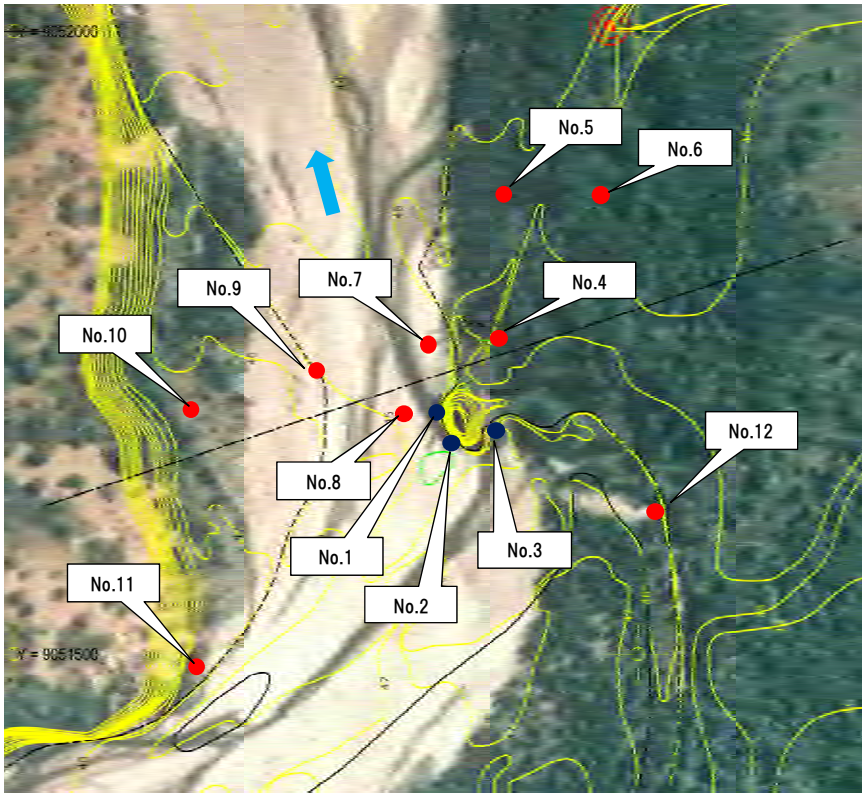
2) Grain Size Distribution

The location map of surveying the grain size is described in Figure 1-6. One of the objectives of surveying of grain size is to grasp the conditions of river foundation for construction. The other objective is to understand the grain condition at the depth of corrosion on flooding.

a) Sand gravels with grain size of less than 20mm are deposited on the ground between 2 to 3m below the surface. The river bed of 2m depth might be carried away due to flood. Since the river bed of up to 2m depth is composed of sand gravel, bed protection works should be considered.

b) Cobble gravel is deposited on the ground deeper than 3m from the surface. The strength is enough for construction of the foundation.

c) Fine-grained fraction was not found on the ground between 3 to 4m below the surface. Since the coefficient of permeability is estimated to be higher, the structure must be provided with the countermeasure against percolation for protection of foundation.



EX. site	Proposed site	grain size
NO.1	Dike Wall	×
NO.2	ditto	×
NO.3	ditto	×
NO.4	Headrace	○
NO.5	Sediment trap	○
NO.6	Main canal	○
NO.7	Scouring	○
NO.8	Fixed weir	○
NO.9	Fixed weir	○
NO.10	Fixed weir	○
NO.11	Dike wall	×
NO12	Dike protection	○

Soil Survey

Ground Condition Survey

Figure 1-6 Site of Soil Survey

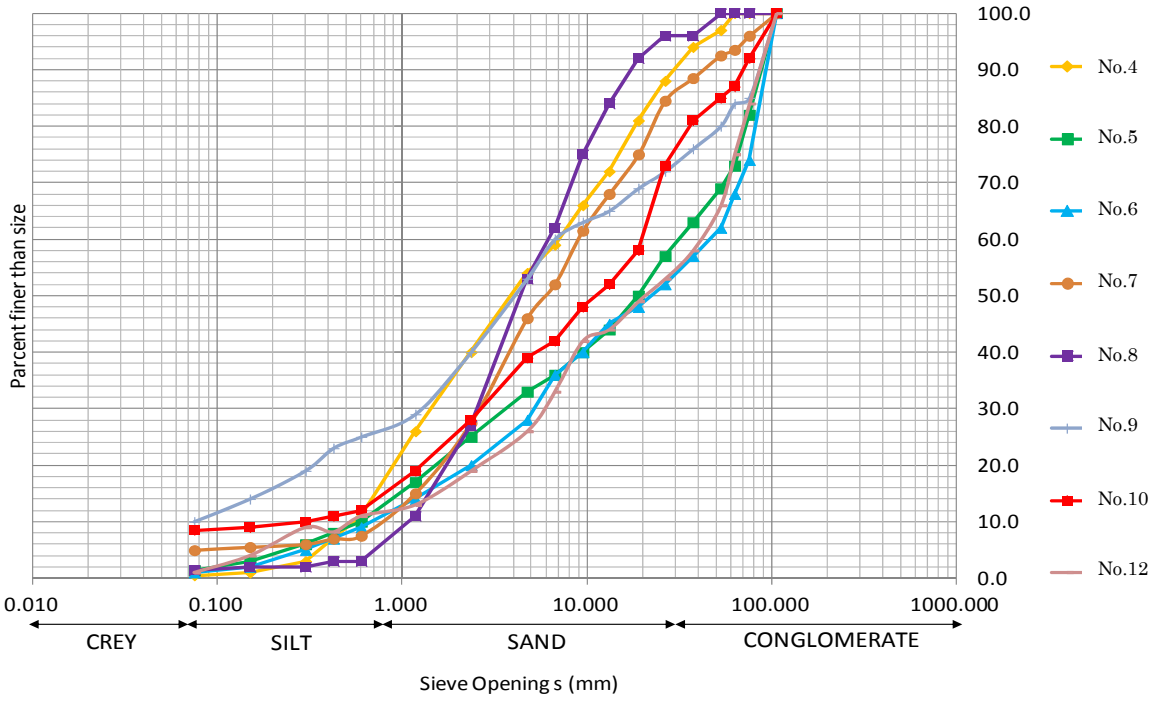


Figure 1-7 Result of Grain Size Analysis

(3) Topographic Survey

Summary of topographic survey is as follows.

1) River Topographic Survey

a) River Longitudinal and Cross Section Survey

	Location	Longitudinal	Cross Section	Remark
1)	Laleia River	11,600m	Interval with 200m	
2)	Vemasse River	7,000m	ditto	
	Total	18,600m		

b) River Protection Survey

	Location	Longitudinal	Cross Section	Remark
1)	Laleia River	Left bank: 800m	Interval with 50 m,	
		Right bank: 300m	ditto	
2)	Vemasse River	900m	Interval with 50 m,	
	Total	1,700m		

2) Irrigation Canal

a) Main canal

	Location	Longitudinal	Cross Section	Remark
1)	Main canal	6,500m	Interval with 50 m,	

b)

	Location	Longitudinal	Cross Section	Remark
1)	Secondary Canal	2,560m	Interval with 50 m,	
2)	Secondary Canal	3,250m	ditto	
3)	Secondary Canal	1,040m	ditto	
4)	Secondary Canal	1,320m	ditto	
5)	Secondary Canal	690m	ditto	
6)	Secondary Canal	670m	ditto	
	Total	9,530m		

3) Longitudinal and Cross Section Survey at Intake Site

	Location	Length	Remarks	Remark
1)	Longitudinal	870m	Interval with 20m	
2)	Cross Section	300m×45sections		

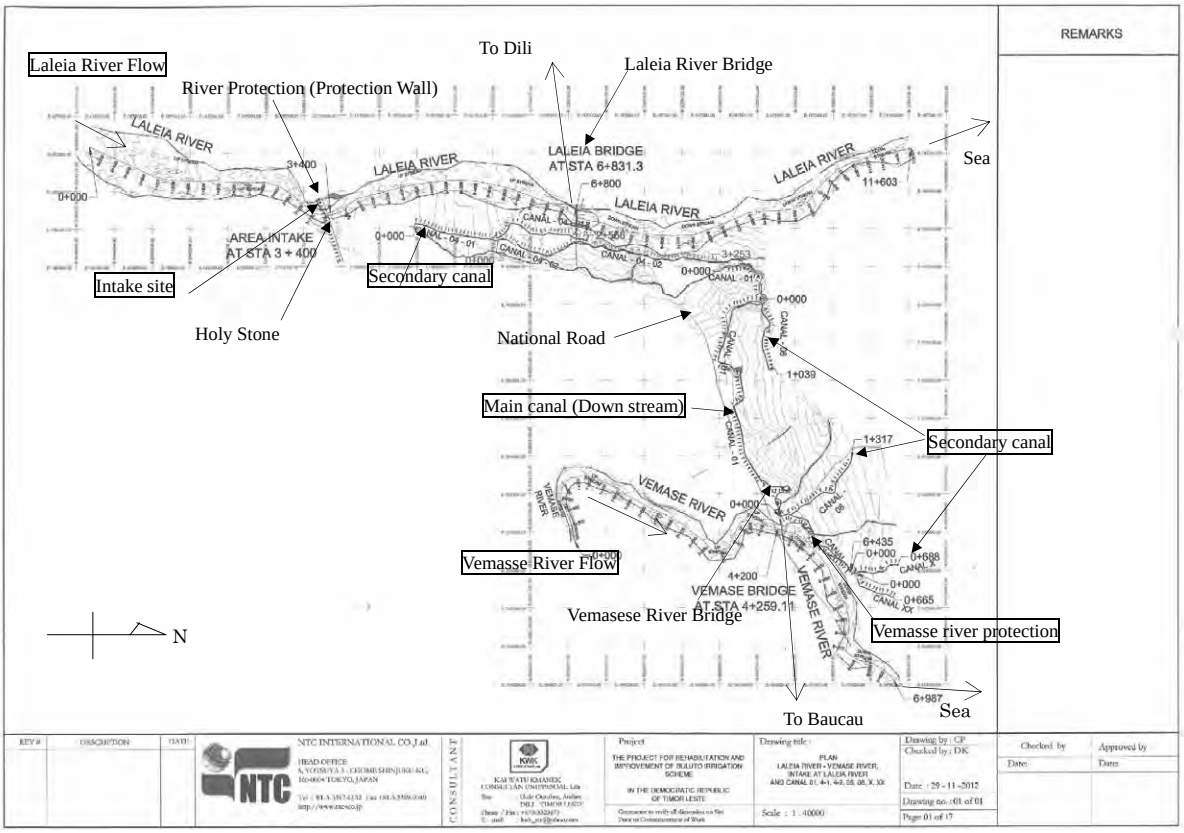


Figure 1-8 General Plan of Topographic Survey

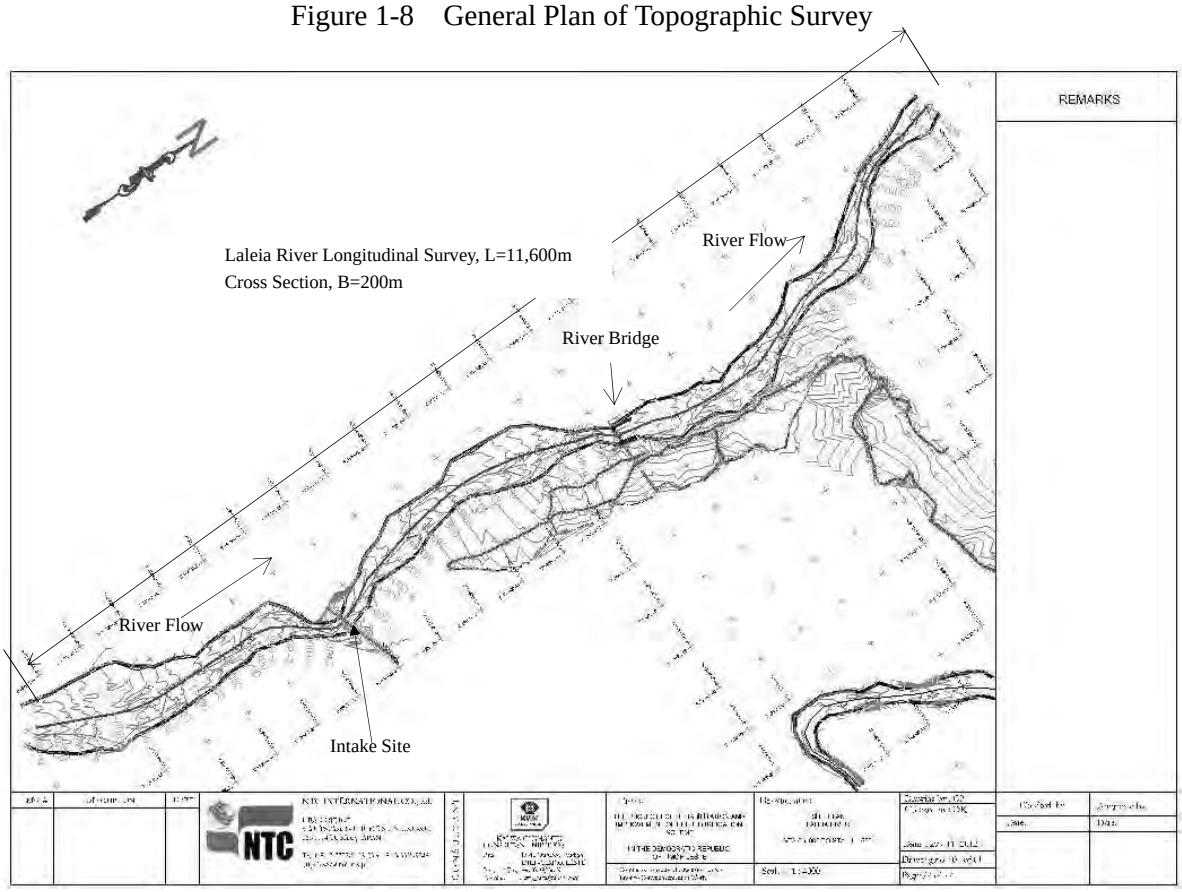


Figure 1-9 Laleia River

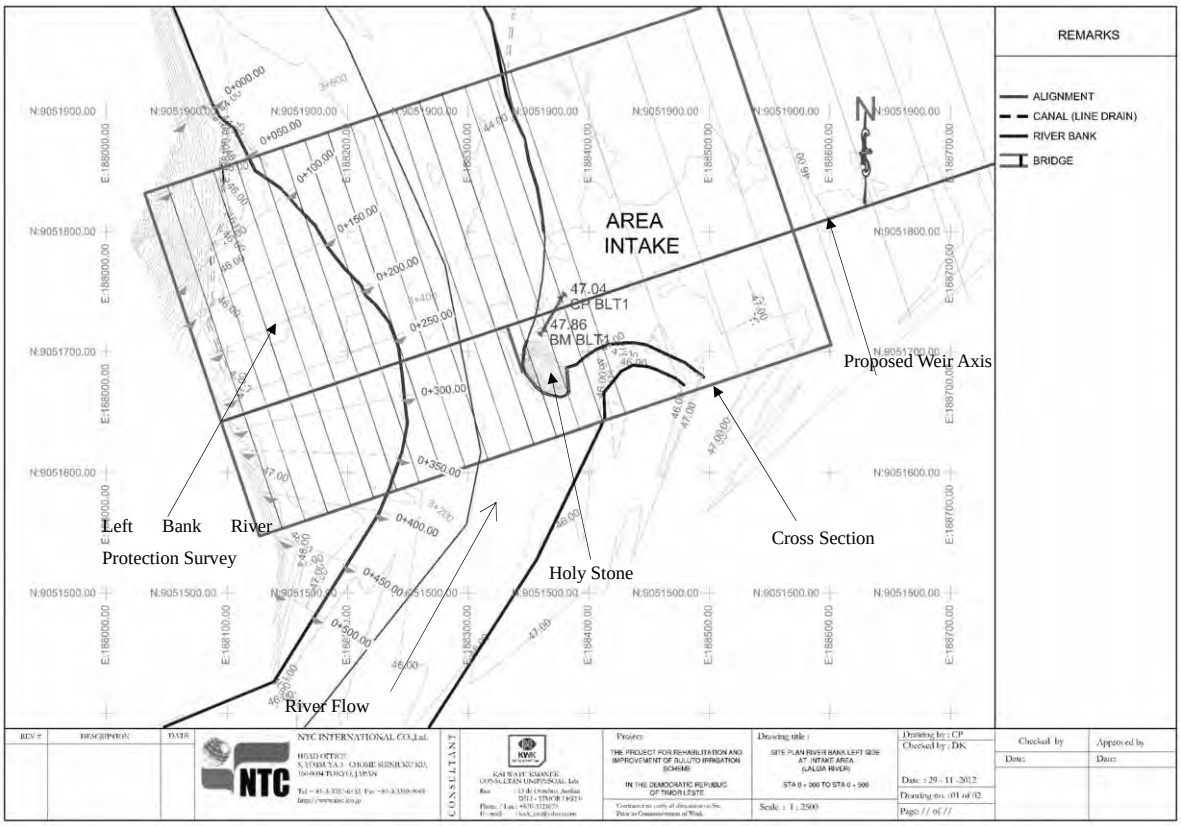


Figure 1-10 Proposed Intake Site

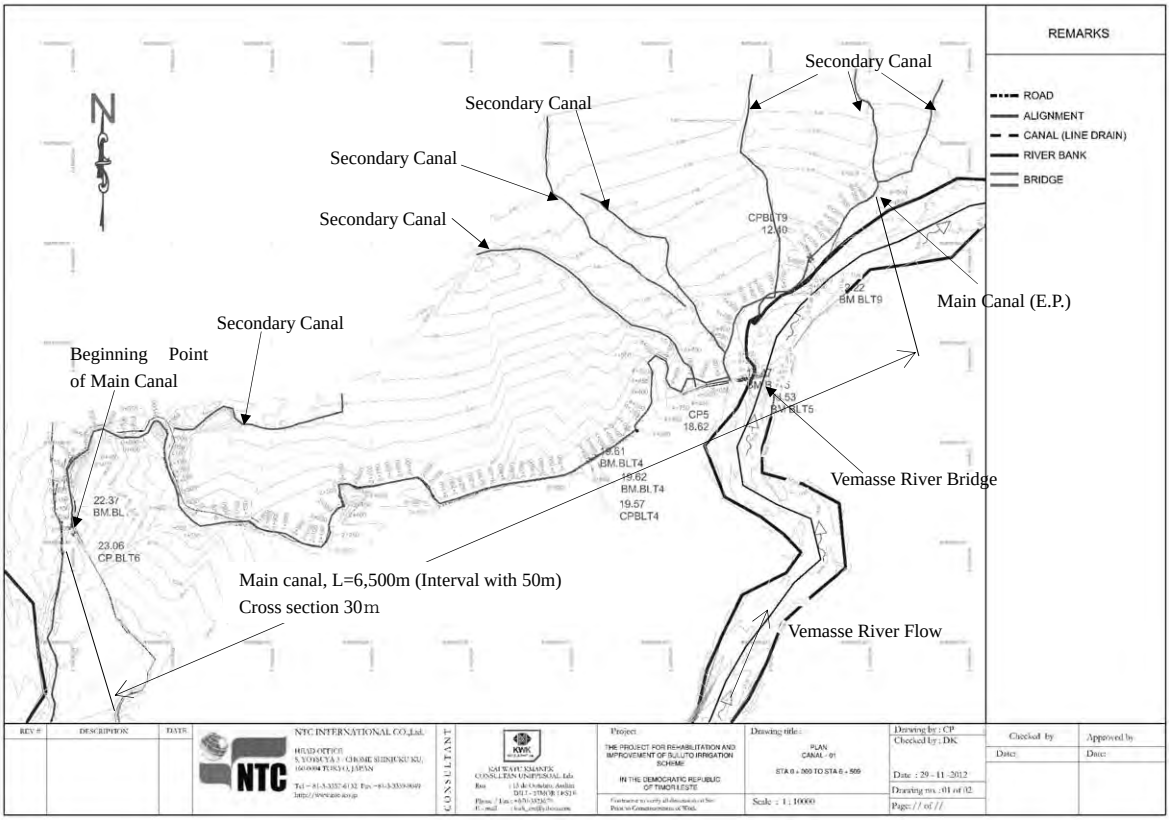


Figure 1-11 Proposed Main Canal

(4) River Discharge Survey

The river discharge survey was conducted to find the variations of water level and discharge of Laleia River. The survey was undertaken from November 2012 to June 2013. The water level survey was conducted on a daily basis and the flood survey was undertaken for 2 times in each month. The location of the survey was at the national road bridge crossing Laleia River.

1) The Result of Daily Water Level Variation

The calculated results of water level survey data are as follows. Comparing the data of monthly average data as described in Table 1-2, the result describes that the timing of increase of river discharge is perceived as late, and the timing of beginning dry season is early. The maximum flood discharge is observed at 190m^3/sec in the survey, and this year might be considered as a dry year.

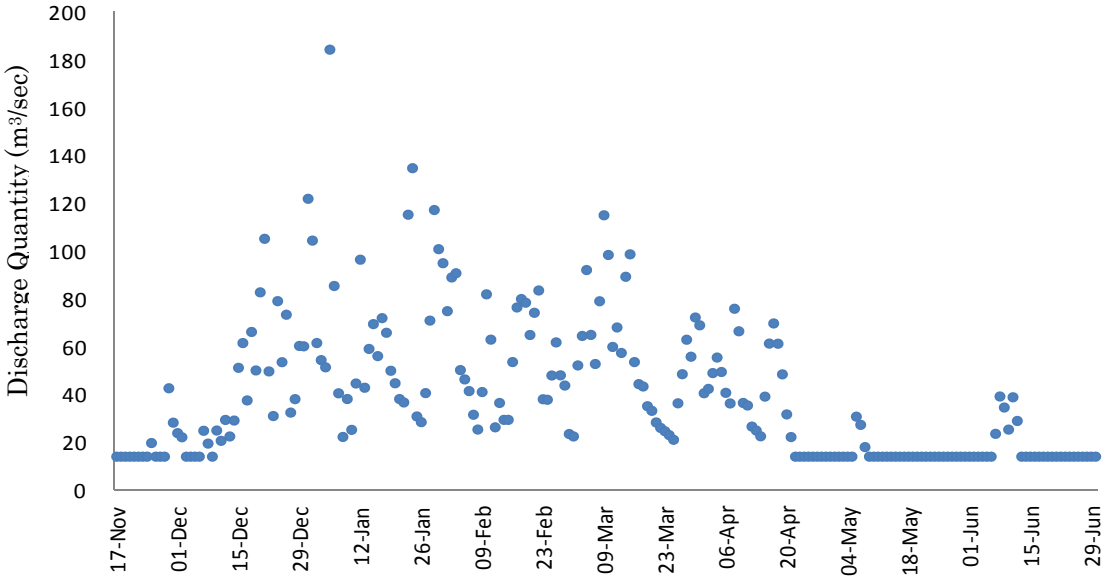


Figure 1-12 Result of Laleia River Discharge Survey

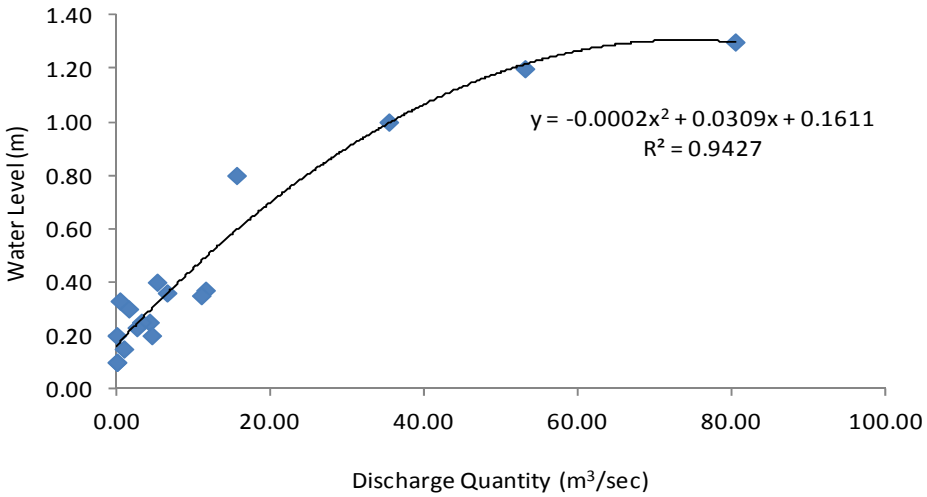


Figure 1-13 H-Q Curve of Result of Laleia River Survey

1-3-5 Agriculture

(1) Agriculture Conditions

1) Rice Self Sufficiency

According to Inter-Ministerial Food and Nutrition Security Task Force, Quarter II 2012, Situation Assessment Report (September 2012 FAO), the status of rice production and demand of RDTL, Baucau, and Manatuto are as shown in the Table 1-4. As indicated in the Table 1-4, whole RDTL especially Dili is in shortage of rice self sufficiency, but Baucau and Manatuto has achieved self sufficiency of rice.

Table 1-4 Production and Demand of Rice

Area	Rice Production (Ton) *1	Demand (Ton)	Excess and Deficiency (Ton)
Whole RDTL	73,977	113,039	-39,062
Dili	156	24,807	-24,651
Baucau	24,171	11,840	12,332
Manatuto	7,302	4,531	2,771

*1: Year of 2011/2012, Milled Rice

Source: National Directorate for Agriculture and Horticulture

2) Rice Production

i) Variety

In Baucau and Manatuto, the recommended varieties of rice are specified as i) IR64, ii) Nakuroma, iii) traditional varieties (ex. Siliaun) and iv) Menbrano.

The Baucau district offices have stocked the Nakuroma variety of seed rice of 30 tons, and provide seed rice to farmers to practice the farming method of Integrated Crop Management (ICM). In the whole Baucau, the area practicing the ICM farming method was 2,862ha in 2011-12. On the other hand, Manatuto district offices have stocked the Nakuroma variety of seed rice of 25 tons. In the whole Manatuto, the area practicing the ICM farming method was 460ha. Therefore, it can be considered that Baucau and Manatuto keep enough quantities of seed rice to introduce ICM farming method.

ii) Production Quantity

The cropping area and production quantity are described in the Table 1-5. The production quantity in Baucau has been increased by more than 5 times during the period from 2006 to 2011. On the other hand, there was a little increase in production quantity and cropping area in Manaturo.

Table 1-5 Cropping Area and Production Quantity in Baucau and Manatuto

District, Area and Production		2006	2007	2008	2009	2010	2011
Baucau	Area (ha)	3,660	4,971	5,071	9,200	10,878	13,225
	Yield (ton)	6,588	7,457	10,193	29,440	43,354	33,021
Manatuto	Area (ha)	4,091	3,450	3,450	4,265	1,571	2,530
	Yield (ton)	8,182	5,157	5,157	12,795	4,072	6,654

Source：MAF, Baucau district office

3) Conditions of Government Support

i) Dissemination of Improved Farming Methods

The district offices of Baucau and Manatuto have introduced ICM farming method supported by GIZ. ICM farming method is a specific farming method to increase the production amount and to improve all the processes from plowing to harvest. Especially, the methods focus on the providing high quality seed, plowing, nursery, transplanting, weeding, harvest timing and others (ICM manual, GIZ). Both the district offices reported that the expansion of ICM farming method have reached 20 to 30% in 2010 (Table 1-6). In 2010, the expansion of Hybrid rice was introduced. However, because of the necessity of a high quantity of application fertilizers, little expansion of hybrid variety was observed.

Table 1-6 ICM Expansion in Baucau and Manatuto (2010), Unit: ha (Rate)

Cultivation Method	ICM + Hybrid	Conventional	Total
Baucau	2,994 (28%)	7,844.4 (72%)	10,838.4 (100%)
Manatuto	314.6 (24%)	1,006.7 (76%)	1,321.3 (100%)

Source：District office of Baucau and Manatuto

ii) Conditions of Providing Support of Fertilizers

The district offices of Baucau and Manatuto provide fertilizer to farmers in case that the farmer introduces ICM farming method. The actual amounts of providing fertilizer from 2009 to 2012 and the schedule in 2013 are shown in the Table 1-7. A high quantity of fertilizer was provided to farmers in 2009. This is because when China introduced hybrid variety, fertilizers were also supplied together. After 2011, 3 to 4 tons of urea fertilizer has been provided. If the farmers apply 100kg/ha fertilizer, then the provided quantity can be applicable only for a limited area of 30 to 40ha.

Table 1-7 Conditions of Providing Support of Fertilizers in Baucau and Manatuto

District	Fertilizer	2009	2010	2011	2012	2013 (Plan)
Baucau	Urea	40.65	90.4	4	4	10
	Phosphate	0.75	12.9	3	4	5
	KCL	0.10	0.4	1	2	5
	NPK	0.45	32.9	0.5		
	Total	41.95	136.6	8.5	10	20
Manatuto	Urea	18.65	18.45	3	4.5	10
	Phosphate	1.95	9.35	2	4.5	5
	KCL	0.3		1	1	5
	NPK	5.9	17.05	0.5		
	Total	26.8	44.85	6.5	10	20

Source: MAF, DNAH, Unit: tons

iii) Conditions of Providing Support of Tractors

MAF provided the tractors to farmers from 2007 to 2009 as shown in the Table 1-8.

Table 1-8 Number of Tractors at Timor-Leste, Baucau and Manatuto

Area	Tractor (Large/Middle Size)	Hand Tractor
Timor-Leste	315	2,424
Baucau	31	371
Manatuto	33	199

Source: MAF, DNAH

According to the document of Baucau district office, nineteen (19) hand tractors were provided to the beneficiary farmers of the project in Vemasse. Further, the agricultural extensions officer of Manatuto reports that fifteen (15) hand tractors were provided to the beneficiary farmers of the project in Laleia. It may be considered that the tractors running successfully are 20, which are 60% out of 34 provided in total.

4) Marketing Conditions

i) Purchase by the Government

Supported by the government, the merchants of Centro Logistic National (CLN) had bought the rice from formers, but such a purchase program was ended in 2005. Currently, there is no CLN office in Baucau. In addition, it is also confirmed from the interview survey of farmers that the CLN had stopped buying rice.

Moreover, some private companies bought rice from farmers around Baucau, Manatuto etc., and the purchased rice was shipped and sold to the government under the support by Ministry of Tourism, Commerce and Industry (MTCI). However, at the present of December 2012, there is no agreement in force to buy the rice from MTCI. Therefore, private companies are not buying the rice.

ii) Price of Rice

There are variation and difference in price between imported rice and domestic rice in 2010 as shown in the Table 1-9. The price of domestic rice increases in November and December in comparison to harvest month of May and June. In November and December, the rice production of dry season can be shipped at a higher price, and therefore the production of dry season is advantageous in terms of price compared to the production in rainy season.

Table 1-9 Price of Imported Rice and Domestic Rice (2010), Unit: US$/kg

Contents	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dili (Imported rice)	0.60	0.80	0.80	0.80	0.80	0.85	0.85	0.75	0.75	0.75	0.75	0.75
Dili (Domestic rice)	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.80	0.80	0.85	0.85

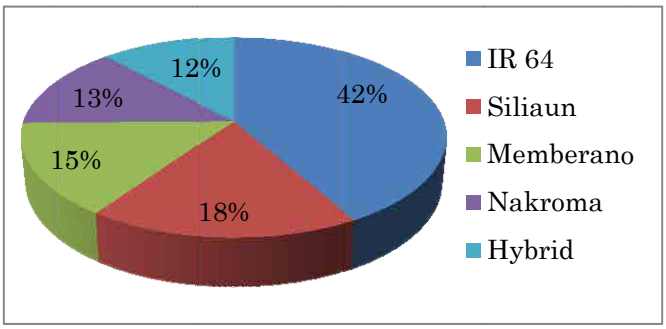
Source: Dili Market Average Price (MOF)

(2) Conditions of Irrigable Area

A survey of farm households were conducted for 67 farmers, who were about 10% of the 600 beneficiary farmers. Besides, interviews were also conducted to the district officer of Baucau and Manatuto and the agricultural extensions officer. The survey results are as follows.

1) Main Variety and Cropping

The varieties used for cropping by 67 farmers are described in the Figure 1-14. Most of the farmers use IR64 which is recommended by both the district offices. The next is Siliaun, which is a local variety. The local varieties are also dominant in the market at Baucau and Manatuto as well as imported rice.



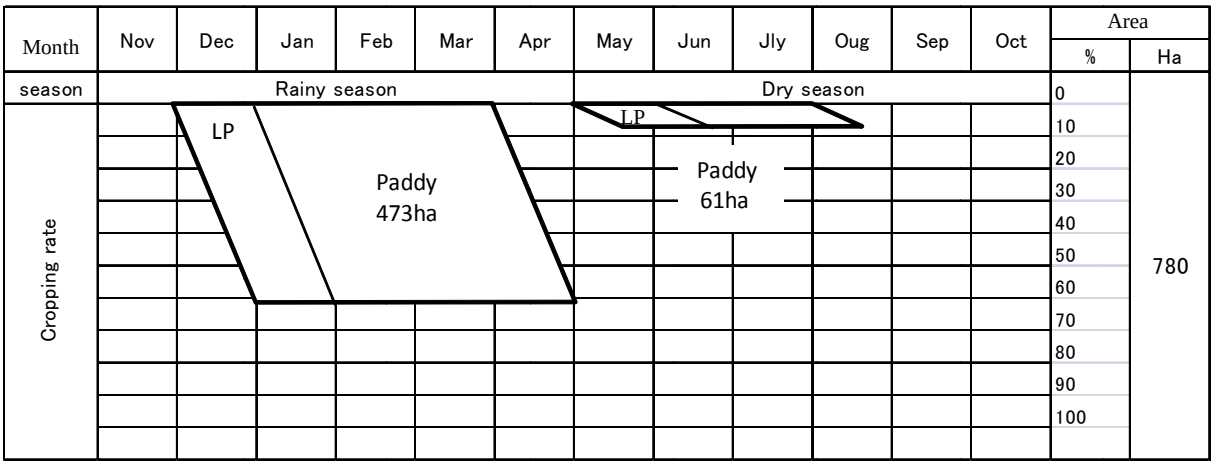
Source: JICA Study Team

Figure 1-14 Rate of Cultivated Rice Variety in the Project Site

Nakuroma variety is also recommended by both the district offices, which is used by 13% of the farmers. Baucau district office is providing Nakuroma variety to expand ICM farming method.

The cropping area is 473ha in the rainy season, and the cultivation is carried out using rain and irrigation water. In the dry season, rice is cultivated in 61ha area using Laleia River water. Apart from rice, a small portion of vegetable cultivation is carried out in this area.

The cropping pattern of Buluto area is as follows.



LP: Land Preparation

Figure 1-15 Cropping Pattern and Cropped Area in Buluto

2) Family Composition and Rice Consumption of each Family

Sixty-seven (67) farm households were interviewed in this survey, and there were 447 persons in

their family. The average size of each family is composed of 6 to 7 persons. As annual amount of rice consumption for each person is 106kg, the amount of 636 to 742kg of milled rice which is equivalent to 1,060 to 1,236kg of husk rice is required for each family. (Inter-Ministerial Food and Nutrition Security Task Force Situation Assessment Report, FAO)

3) Farming Scale

The farming scale for 67 famers is shown in the Table 1-10. The medium and average farming scale are 1.5 to 2.0 ha, and 1 to 2 ha accounts for about 50% of the total area.

Table 1-10 Distribution of Farming Scale

Farming Scale		Frequency of Distribution (Farmers)	
Maximum	12 ha	Under 1ha	12
Minimum	0.5 ha	1-2ha	35
Average	1.87 ha	2-5ha	17
Medium	1.50 ha	Over 5ha	8

Source: JICA study team

4) Rice Production

The rice production for 67 farmers is shown in the Table 1.11 from the result of hearing investigation. The median and average yields are around 2 ton/ha, and about 65% of the farmers attained an yield of 1 to 3 ton/ha.

Table 1-11 Distribution of Yield per ha

Yield per ha		Frequency Distribution (Farmers)	
Maximum	5.8 ton/ha	Under 1 ton/ha	9
Minimum	0.4 ton/ha	1-2 ton/ha	23
Average	2.14 ton/ha	2-3 ton/ha	21
Median	2.07 ton/ha	Over 3 ton/ha	14

Sauce：JICA study team

The average cultivated area in the beneficiary area is 479 ha in rainy season, and 61 ha in dry season. Therefore, it is estimated that the total amount of rice accounts for around 1,000 ton in the Project area.

5) Allocation of Agricultural Extension Officers

One agricultural extension officer is allocated for one village (suco) normally. In the beneficiary area, two agricultural extension officers are allocated in Vemasse village. In Laleia sub district, one extension officer is allocated in Rifau village and Hatulalan village each. Since the extension

officers are well aware of the conditions of the beneficiary area, it is considered that there is no problem in respect to allocation of extension officers.

6) Tractor and Animal Draft

i) Hand Tractor, Large Size Tractor and Animal Draft

Generally, the ability of hand tractor for plowing is 15 ha/unit/season. Presently, 20 units of hand tractors are operated successfully. The hand tractors are provided by the government and 1 unit is used by a group of 15 to 20 farmers. Therefore, much time is needed for all the members of the group to plow their own farm. On the other hand, the progressive farmers possess their own hand tractor. Since these tractors are mainly used in the farmlands of these progressive farmers, the farmers who do not have their own tractor are using the tractor provided by the government or using the animal draft for plowing.

Since only 13 farmers out of 67 farmers are raising cows or buffalos, the animal draft is performed only in a limited area. When the soil becomes too hard to plow by the hand tractor before the rainy season, the farmers sometimes use animal draft for plowing before the usage of hand tractor. However, during cultivation in dry season, cows or buffalos sometimes enter into the field and bring damages to the crops by eating and pushing down the crops.

Both the district offices lend some tractors (large and middle size) to farmers. The plowing ability of these tractors is around 50 ha/unit/season. The farmers can use these tractors by paying fuel cost for these tractors. Five to six tractors are available for farmers in Vemasse sub-district from Baucau district office in a year. Out of five to six tractors, three to four tractors may be used in the beneficiary area. Further, the agricultural extension officer of Rifau village said that about two tractors of large size are used in the beneficiary area of Leleia sub-district. In total, five tractors are available in the beneficiary area.

ii) Plowing by Hand Tractor and Large Size Tractor

The area which can be plowed in the existing situation by tractors may be up to 550ha (15ha x 20units + 50ha x 5units =550ha).

Since the hand tractors have not been handed to the farmers after 2010, it may be difficult to increase the crop area, if the irrigable area will be increased by the Project. Therefore, the area which can be plowed after 3 years of completion of the Project will be 540ha i.e. 15% increase from the existing cropping area of 473 ha. The area after 5 years of completion is expected to increase, because the willingness of famers will be improved by increasing the irrigation water and repairing the national road between Dili and Baucau for marketing. Moreover, as the farmers will be able to sell the surplus rice and the income of farmer will be increased, they may also be able to lend a hand tractor or provideconduct tractor services. If the number of tractors owned by the individual

farmersis same among the personal's own and the government's will be the sameown, about 40 hand tractors will be operated in the beneficiary area, and 40 the hand tractors can plow an area of 850 ha, exceeding the 780ha ofas expected irrigable area.

7) Post Harvest

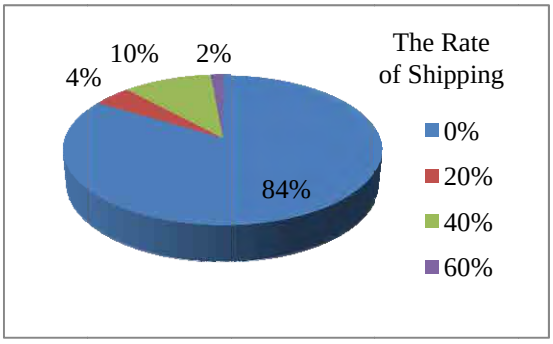
Thirty five (35) to forty (40) of threshing machines and five (5) to seven (7) polishing machine has been operated in the beneficiary area including personal use. The threshing machine can thresh 1 ton/day and 35 to 40 units can thresh 1,050 to 1,200 tons of rice from June to July at the peak period. The polishing machine can polish 1 to 3 ton/day. If the operating rate is 20%, 5 to 7 units can polish 1,000 to 1,500 tons rice. These numbers indicates the ability for post harvesting of 1,000 tons, which are equivalent to production quantity of rice in the beneficiary area.

The post harvesting facility may be operated by private by collecting some crops or some money under the cooperation among the farmers. However, it is needed to support threshing machine especially from the government, when the production will be increased rapidly after rehabilitation of the irrigation facilities.

8) Shipment of Rice

Eighty four (84) % of the 67 farmers have not shipped their surplus rice. On the other hand, some farmers are considering shipping, since 12% of farmers have shipped 40% of production amount.

After the rehabilitation of irrigation facilities, the amount of surplus rice will be increased owing to increase of irrigable area in dry season. It is important to establish the system for collecting and shipping of surplus rice by the leader like a progressive farmer who already has the experiences of shipping.



Sauce：JICA study team

Figure 1-16 Rate of Shipping Surplus Rice

1-4 Environmental and Social Considerations

1-4-1 Outline of Project Components Affecting to Environment and Social Conditions

The project consists of six (6) main components including 1) irrigation facilities, 2) drainage canal, 3) river works, 4) architecture, 5) pilot plots and 6) soft component. The major specifications of the components are summarized in the following table.

Table 1-12 Main Components of the Project

Item	Component	Specification
1.Irrigation Facilities	Intake Facilities	Fixed type weir: L=200m, included sand sluice gate of B=7.1m
		Sediment trap: L=50m, B=8m (4m x 2 lines)
		Headrace canal: L=236.24m, included sediment trap and transition canal
		River revetment (concrete guide wall): H=9.6-8.1m
		River training bank (earth embankment) at river bank: H=7-8m
		Gate operation house: operator's room A=30m^2, storage space for equipment A=30m^2
		Pipeline on left bank side of weir
	Irrigation Canal	Main irrigation canal: masonry lining, L=12.3m
		Secondary irrigation canals: earth lining, n=16 lines, L=15.4km
		Appurtenant works: diversion works, drop works, drainage crossing works, gate works, etc.
		Canal maintenance road: gravel pavement, L=1.3km (new extension)
2. Drainage canal	Drainage canal	Drainage canal: earth canal, N=2 lines, L=4.6km
		Dispersion weir: N=4 places
3. River works	River revetment	River protection dike: gabion type, L=600m, H=3.0m
4. Architecture	Meeting facilities for WUA	Office and meeting room: A=87m^2 Toilet room: A=17.5m^2
5. Pilot plots	Farm plot consolidation	Consolidation of farm plot band: N=2 places, A=0.6 ha
6. Soft component	Establishment and enhancement of WUA	Establishment of WUA, training of water management techniques, technical transfer of operation and maintenance of irrigation facilities

1-4-2 Baseline Situation of Environmental and Social Conditions

The United Nations Development Programme (UNDP) has collected and arranged information on natural environment in Timor-Leste, focusing on "environment and sustainable development". The "National Biodiversity Strategy and Action Plan (NBSAP) of Timor-Leste 2011-2020" was prepared as a framework to conserve its biodiversity and serves as a safeguard in achieving the country's development agenda in the next two decades.

There were 15 conservation areas established during the United Nations operation period in Timor-Leste. In 2007, the first national park, "Nino Konis Santana National Park", was declared, combining 3 conservation areas. And additional 17 protected areas were identified by the Department of Protected Areas and National Parks in 2007. The project area is not located in these conservation areas, as shown in the figure below. Furthermore, the rehabilitation project is not expected to make significant impact on the ecology and natural conditions.

Source: The National Biodiversity Strategy and Action Plan of Timor-Leste; National Biodiversity Working Group; 2011

Figure 1-17 Protected and Conservation Areas in Timor-Leste

The Project area is administratively located in Laleia sub-district of Manatuto district and Vemasse sub-district of Baucau district. At the village (suco) level, 2 of 3 villages of Laleia district (Lifau and Hatu-Ralan) and 1 of 7 villages of Vemasse sub-district (Vemasse) are related to the Project area. The number of households and population are tabulated in the following table by village and sub-village (Aldeia). The total number of households and population of the 3 villages are 1,063 families and 4,934 parsons, respectively.

Table 1-13 Demographic Information in the Project Area

Sub-district	Suco (Village)	Aldeia (Sub-village)	Household	Population
Laleia	Lifau	Total	**277**	**1,084**
		Uma Rentau	133	512
		Lemao	65	260
		Uma Clalan	79	312
	Hatu-Ralan	Total	**207**	**894**
		Ralan	74	317
		Beboro	92	400
		Umaluk	41	177
Vemasse	Vemasse	Total	**579**	**2,956**
		Loa	146	836
		Raha	145	623
		Betulale	127	715
		Oralah	161	782

Note: Demographic information in Laleia and Vemasse sub-district is as of 2012 and 2010/11, respectively.

1-4-3 System and Institutions Relevant to Environmental and Social Considerations

(1) Procedures by the Proposed Environment Guidelines in Timo-Leste

According to "Guideline #1: Environmental Requirements for Development Proposal" stated in the proposed "Environment Guideline (draft)" that is currently being implemented in Timor-Leste, the developer (the developer of Buluto Project is MAF) of new and improvement projects is required to submit an application to the Secretary of State for Environmental (SSE) and to secure approval on the contents of the development plan.

Accordingly, prior to the project implementation, MAF shall provide an Environmental Management Plan (EMP) and obtain permission from SSE as a prerequisite procedure to implement the Project. The Project for Improvement of Buluto Irrigation Scheme is related to "IX. Agricultural, Livestock and Forestry Sectors and 1. Irrigation systems (including irrigation and drainage infrastructure)" in the 12 sectors classified by the Decree-Law No. 5/2011 of 9 February, 2011. Also the item subject to regulation in the Project implementation corresponds to "1. Irrigation system" in "IX. Agricultural, Livestock and Forestry Sectors" as shown in Table 1-14.

Table 1-14 Categories of Agricultural, Livestock and Forestry Sectors

Items	Category A	Category B	Buluto
IX. Agricultural, Livestock and Forestry Sectors			
1. Irrigation systems	≥ 100 ha	< 100 ha	780 ha
2. Clear the soil for conversion to agriculture	≥ 100 ha	< 100 ha	N.A.
3. Plantations	≥ 20 ha	< 20 ha	N.A.
4. Forests for logging	≥ 25 ha	< 25 ha	N.A.
5. Development of rice fields in forest area	≥ 3 ha	< 3 ha	N.A.

Source: Decree-Law no. 5/2011 on Environmental Licensing
Note: N.A.: Not Applicable

The command area for the Buluto irrigation schemes is about 780 ha that are presently used for rice cultivation under traditional irrigation system. The area is larger than 100 ha, but the Project is a rehabilitation project in the existing paddy field. As there is no land development in the Project, the Project is expected to be categorized as the Category B. For the purposes of environmental licensing, the projects classified as Category B are subjected to implementation of Initial Environmental Examination (IEE) and preparation of Environmental Monitoring Plan (EMP) in the following steps.

a. Preparation of Project Document

b. Implementation of Public Consultation, if required

c. Implementation of Initial Environmental Examination (IEE)

d. Preparation of Environmental Monitoring Plan (EMP)

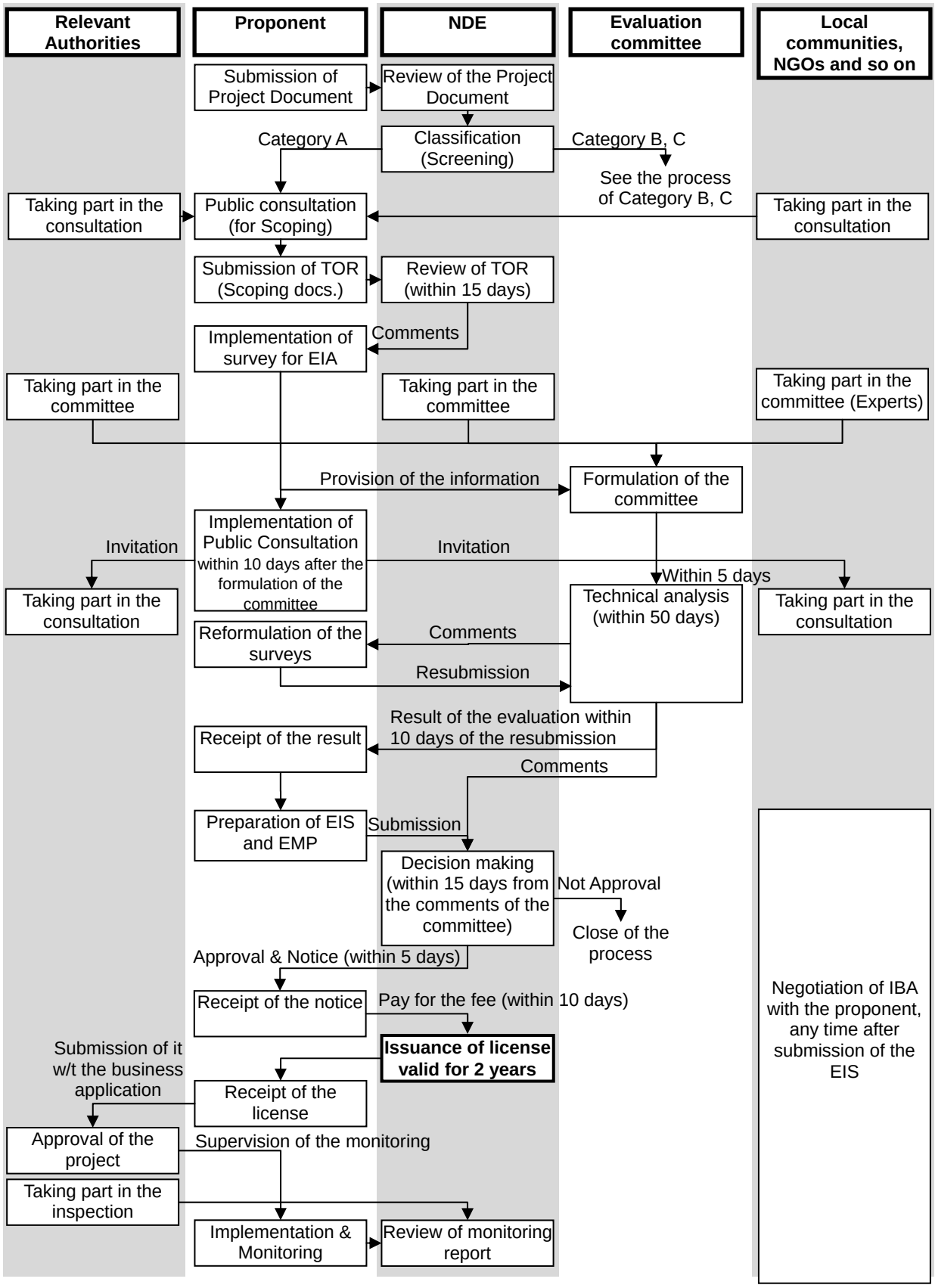


Figure 1-18 Process for Category A Project

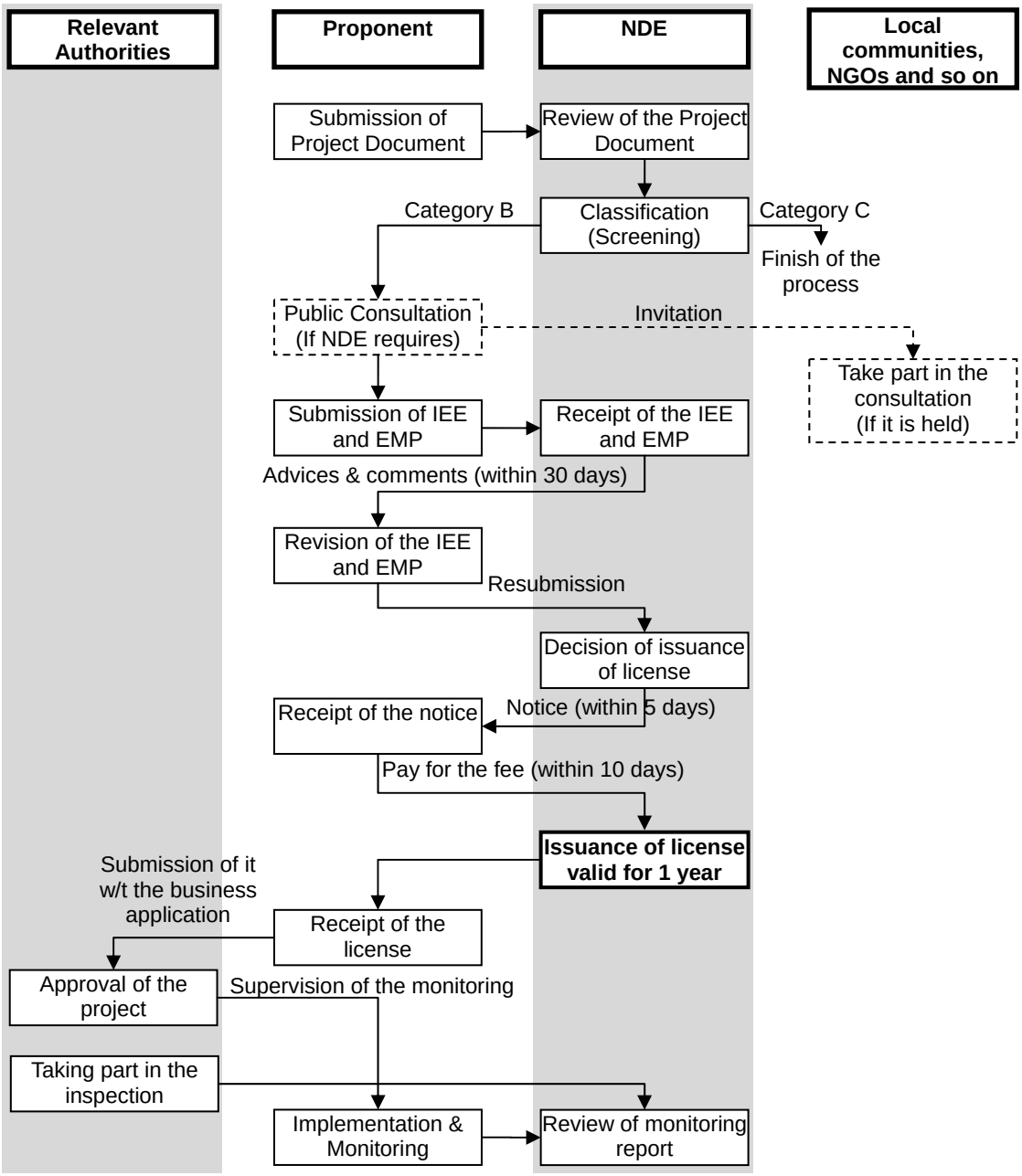


Figure 1-19 EIA Process for Category B Project

(2) Related Organizations in Timor-Leste

The public organizations related to the Project are tabulated in the following table. The Ministry of Agriculture and Fisheries is the implementing agency of the Project. The National Directorate of Environment of the Ministry of Commerce, Industry and Environment and the National Directorate of Land, Property and Cadastral Services of the Ministry of Justice is closely related to the environmental

aspects of the Project.

Table 1-15 Organizations Related to the Project

Ministry	Directorate	Role	Contribution to Project
Ministry of Agriculture and Fisheries	ND of Policy and Planning	Planning and budget management of Ministry	Support on land acquisition
	ND of Irrigation and Water Management	Implementation and monitoring/evaluation of irrigation schemes	Support on operation and maintenance of the irrigation facilities
	ND of Forestry	Management of natural environment	
District Agriculture Office	Directorate of Planning and Finance	Agricultural extension services	Support on land acquisition
District and Sub-district administration	Manatuto and Baucau district, Laleia and Vemasse sub-district		Administrative arrangement of local administration
Ministry of Commerce, Industry and Environment	ND of Environment	Management of environmental impact assessment	Issuance of license after environmental evaluation
Ministry of Justice	ND of Land, Property and Cadastral Services	Registration and management of land	Direct support on land acquisition

The Department of EIA of the National Directorate of Environment of the Ministry of Commerce, Industry and Environment has responsibility for the environmental assessment of the Project. The organization chart of the National Directorate of Environment is as follows.

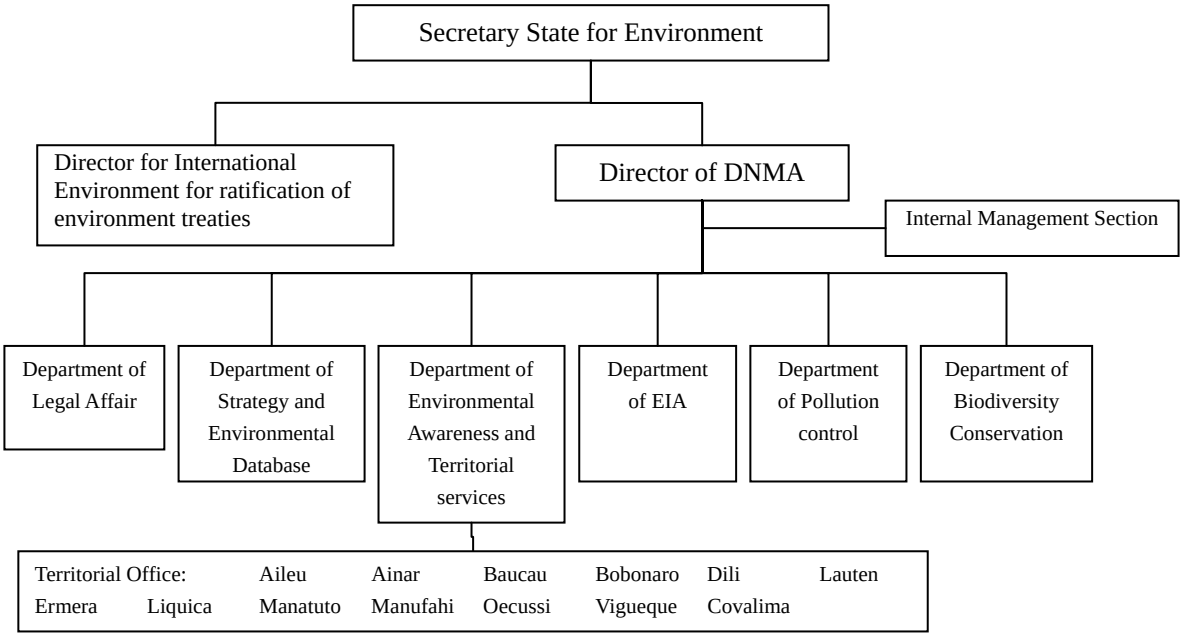


Figure 1-20 Organization of National Directorate of Environment

Regarding land acquisition, the National Directorate of Land, Property and Cadastral Services of the Ministry of Justice has the responsibility. Regarding natural conservation, the Department of

Forestry of the Ministry of Agriculture and Fisheries has the responsibility.

1-4-4 Alternatives

The project is evaluated to be economically feasible, since the project will have a significant impact on the rice production of the area. Therefore, the project shall be realized to improve the agricultural production in the target area.

The layout and design of the main project components, i.e., intake weir, irrigation canals and drainage canals was carefully decided taking in consideration of cost effectiveness of the project.

To minimize the area of land acquisition for irrigation canals and maintenance roads, the suitable layout and design of the facilities were reviewed as follows.

- Shape of canals: The width of the canals was reduced by changing the cross section of canals from trapezoidal section to rectangular section or by installing box culvert in the portion of residential areas along the main canal.
- Layout of maintenance road: The length of the roads was reduced by using of the existing roads for maintenance at some sections.

1-4-5 Scoping on Environmental and Social Considerations

In regard to 29 items of potential impacts, the scoping was carried out assuming the general conditions of the irrigation project in Timor-Leste. The scoping was carried out for the pre-construction and construction stage and operation stage. The result of the scoping is summarized in the following table.

Table 1-16 Scoping of Potential Impacts

		Potential Impact	Rating		Brief Description
			Pre-const. / Const. Stage	Operation Stage	
Pollution	1	Air pollution	D	D	No significant impact is anticipated.
	2	Water pollution	B-	B-	Muddy water in construction period and agrichemicals pollution in operational stage are anticipated.
	3	Waste	C-	D	General industrial waste, sedimentation, and other wastes are anticipated in construction phase.
	4	Soil pollution	D	C-	Slight agrichemical pollution is anticipated due to expansion of irrigated area.
	5	Noise and vibrations	C-	D	General noise and vibration might be observed during construction.
	6	Ground subsidence	D	D	No significant impact is anticipated.
	7	Offensive odors	D	C-	New additional points of offensive odor are anticipated due to promotion of agricultural activities.
	8	Bottom material	D	C-	Sedimentation condition in water environment might be affected due to hydrological changes in the case that irrigation development plan is implemented.

		Potential Impact	Rating		Brief Description
			Pre-const. / Const. Stage	Operation Stage	
Natural Environment	9	Biosphere reserve	D	D	No significant impact is anticipated.
	10	Biota and ecosystems	C-	D	Slightly and temporary impact in limited area is anticipated during construction period.
	11	Hydrometeor	D	C-	Run off conditions might be slightly affected due to hydrological changes in the case that irrigation development plan is implemented.
	12	Topographic and geologic features	D	D	No significant impact is anticipated.
Social Environment	13	Involuntary resettlement	C-	D	In the case that the projects cause land acquisition or temporal occupation of private land, small scale of involuntary resettlement and rental are anticipated.
	14	Indigenous or ethnic people	C+/-	C+/-	Agricultural productivities, as main income source of indigenous people, are improved with some small risk of unfair distribution of project benefit.
	15	Local economies, such as employment, livelihood, etc.	C+	B+	Economical benefit is anticipated for rural society including farmers' income situation.
	16	Land use and utilization of local resources	D	B+/C-	Appropriate farmland use improves the management of abandoned land with slightly negative impact such as new natural resources extraction including water, forest, and so on.
	17	Water usage	B-	B+	Although available irrigation water discharge might temporarily be reduced during construction, water availability would be ensured by the project.
	18	Existing social infrastructures and services	D	B+	Existing social infrastructure and services are only positively changed due to rehabilitation of agricultural infrastructure.
	19	Social institutions	D	B+/C-	Irrigation development plan and following implementation strengthened rural community and relevant organizations. Negative impact such as water conflict is anticipated in the case that appropriate distribution is not considered.
	20	Misdistribution of benefits and damages	D	D	No significant impact is anticipated.
	21	Local conflicts of interest	D	D	No significant impact is anticipated.
	22	Cultural heritage	D	C-	Irrigation Development Plan may cause some impact on traditional water management system and other customs.
	23	Scenery	D	D	No significant impact is anticipated.
	24	Gender	D	C+	Access to domestic water might be improved.
	25	Children's rights	D	C+	Access to domestic water might be improved.
	26	Infectious diseases such as HIV/AIDS	D	D	No significant impact is anticipated.
	27	Condition of working	D	D	No significant impact is anticipated.
Others	28	Accidents	B-	D	There might be risks of accidents during construction.
	29	Global weather	D	D	No significant impact is anticipated.

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

1-4-6 Terms of Reference to Survey on Environmental and Social Considerations

As for the items evaluated as "B-" in the scoping, which are water pollution, water use, and accidents, survey items and methods on environmental and social considerations are proposed. The terms reference (TOR) of the survey are described in the following table.

Table 1-17 TOR for the Survey on Environmental and Social Considerations

	Potential Impact	Survey Item	Survey Method
2	Water pollution	Impacts during construction stage, Impacts during operation stage	• Identification of location with potential impacts on water quality during construction period • Interview survey on impacts on water quality by fertilizer or agro-chemicals applied in paddy fields
17	Water usage	Impacts during construction stage	• Survey on present irrigation water supply system • Survey on impacts by limitation of irrigation water supply during construction period
28	Accidents	Accidents during construction stage	• Confirmation of items, scale, methods, location, period, kinds of construction equipments and number of vehicles for construction • Confirmation of location of construction sites and residential areas

1-4-7 Results of Survey on Environmental and Social Considerations

The results of the survey on environmental and social considerations are summarized in the following table.

Table 1-18 Results of the Survey on Environmental and Social Considerations

	Potential Impact	Survey Item	Survey Result
2	Water pollution	Impacts during construction stage, Impacts during operation stage	• Turbidity of water in the Laleia river is anticipated during the construction of the intake weir on the upstream of the river. As there are no intake facilities of domestic water or flourishing fishery in the downstream area, the negative impact is not very serious. But the periodical monitoring of water in the river is recommended. • Fertilizers and agro-chemicals will be used in the irrigated paddy fields during the operation period. However, it is not caused by the Project because the target area lies on the existing paddy fields. Further, there are no reports of harmful water pollution by farming in the area in the past.
17	Water usage	Impacts during construction stage	• The irrigation water supply in the existing irrigated paddy fields will be temporarily limited during the rehabilitation of the existing irrigation canals.
28	Accidents	Accidents during construction stage	• The construction will bring potential risk of accidents by increased traffic of vehicles and operation of construction equipments. Especially, construction of canals along the national highway will need a lot of attention to avoid accidents.

1-4-8 Evaluation on Environmental and Social Considerations

The contents and level of the negative or positive impacts were evaluated at the site by using the attached check list. The results of the evaluation are described in the following table. The negative impacts caused by the Project are subjected to the mitigation measured, as mentioned hereinafter.

Table 1-19 Evaluation Results of Potential Impacts

		Potential Impacts	Rating		Brief Description
			Pre-const. / Const. Stage	Operation Stage	
Pollution	1	Air pollution	B-	D	Dust and gas emission might be caused from heavy machinery and vehicles during construction works.
	2	Water pollution	B-	D	Construction works of intake weir and canals may cause deterioration of water quality.
	3	Waste	B-	D	Increase of construction and domestic waste might be caused by construction works and inflow of workers.
	4	Soil pollution	B-	D	Soil contamination might be caused by increased use of fertilizers for pasture reproduction.
	5	Noise and vibrations	B-	D	Noise and vibration may be caused by construction works.
	6	Ground subsidence	D	D	No significant impact is anticipated.
	7	Offensive odors	D	D	No significant impact is anticipated.
	8	Bottom materials	D	D	No significant impact is anticipated.
Natural Environment	9	Biosphere reserve	D	D	No significant impact is anticipated.
	10	Biota and ecosystems	D	D	No significant impact is anticipated.
	11	Hydrometeor	D	B-	Intake weir constructed in the river might change water flow
	12	Topographic and geologic features	D	D	No significant impact is anticipated.
Social Environment	13	Involuntary resettlement	B-	B-	No involuntary resettlement is anticipated, but land acquisition for canal construction is expected.
	14	Indigenous or ethnic people	D	D	No significant impact is anticipated.
	15	Local economies, such as employment, livelihood, etc.	B+	B+	Construction work might provide employment opportunity to local people. Reinforced irrigation schemes would be beneficial to rural livelihoods.
	16	Land use and utilization of local resources	B-	B+	Although some farmland area might be reduced along the canals, irrigation water availability would be ensured by the project.
	17	Water usage	B-	B+	Although available irrigation water discharge might temporarily be reduced during construction, water availability would be ensured by the project.
	18	Existing social infrastructures and services	B-	D	Traffic on the national road might be controlled during the construction stage.
	19	Social capital and institutions	B-	B-	The coordination among the organization concerned might be necessary because the project area is located in two districts (sub-districts).
	20	Misdistribution of benefits and damages	B-	B-	There might be beneficial and non-beneficial farmers in the same community.
	21	Local conflicts of interest	B-	B-	There might be beneficial and non-beneficial farmers in the same community.
	22	Cultural heritage	D	D	No significant impact is anticipated.
	23	Scenery	D	D	No significant impact is anticipated.
	24	Gender	D	D	No significant impact is anticipated.
	25	Children's rights	D	D	No significant impact is anticipated.
	26	Infectious diseases such as HIV/AIDS	D	D	No significant impact is anticipated.
	27	Condition of working	D	D	No significant impact is anticipated.
Others	28	Accidents	B-	D	There might be risks of accidents during construction.
	29	Global weather	D	D	No significant impacts to outside of the area and global weather are anticipated.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
D: No impact is expected.

1-4-9 Mitigation Measures against Impacts and Cost

The mitigation measures against possible impacts on environmental and social aspects shall be taken in construction stage and operation stage, as shown in the following table.

Table 1-20 Major Mitigation Measures against Impacts

No.	Impacts	Mitigation Measures	Implementing Organization	Responsible Org.	Cost
Construction Stage					
1	Air pollution	Spray water at the construction site near residential area so as not to produce so much dust.	Contractor	MAF	Construction cost
2	Water pollution	Provide notice to local communities in advance about extreme mud flow in the Laleia river. Promote proper management of the materials which may affect water quality, for example oil and liquid waste.	Contractor	MAF	Construction cost
3	Waste	Promote proper management of the solid waste and surplus soil, and keep them away from residential area.	Contractor	MAF	Construction cost
4	Soil pollution	Promote proper management of the materials which may affect water quality, for example oil.	Contractor	MAF	Construction cost
5	Noise and vibrations	Operate heavy equipment only in the daytime at sites near residential area. Equip properly tuned and well maintained heavy equipment and vehicles not to produce unpleasant noise.	Contractor	MAF	Construction cost
13	Involuntary resettlement	Explain the project framework and discuss land issues with residents well to reach agreement on land acquisition before construction. Provide opportunities for discussions on land issue to local people periodically for smooth land acquisition, coordinating with the National Directorate of Land, Property and Cadastral Services. Establish the third party organization to coordinate and manage grievances on land acquisition.	District Agr., Local Gov.	MAF	Administration cost
16	Land use and utilization of local resources	Prepare the construction plan properly to minimize restriction of land use during the construction. Provide notice to local communities in advance on the limitation of land use when necessary.	District Agr., Local Gov.	MAF	Administration cost
17	Water usage	Prepare the construction plan properly to minimize restriction of irrigation water supply during the construction. Provide notice to local communities in advance on the limitation of irrigation water supply when necessary.	District Agr.	MAF	Administration cost
18	Existing social infrastructures and services	Provide notice to local communities in advance on the schedule of construction along the national road. Put traffic control staffs to minimize traffic congestion at the construction site along the national road.	Contractor	MAF	Construction cost
19	Social capital and institutions	Explain the project framework to local administrations and residents to come to their understandings. Coordinate the potential imbalance between Laleia and Vemasse sub-district in regular meetings.	District Agr., Local Gov.	MAF	Administration cost

No.	Impacts	Mitigation Measures	Implementing Organization	Responsible Org.	Cost
20	Misdistribution of benefits and damages	Explain the project framework to residents to come to their understandings. Coordinate the potential imbalance between Laleia and Vemasse sub-district in regular meetings.	District Agr., Local Gov.	MAF	Administration cost
21	Local conflicts of interest	Explain the project framework to residents to come to their understandings. Coordinate the potential imbalance among residents in regular meetings.	District Agr., Local Gov.	MAF	Administration cost
28	Accidents	Put traffic control staffs to minimize traffic congestion at the construction site along the national road. Let the workers know the daily work plan and safety measures. Maintain construction machinery properly.	Contractor	MAF	Construction cost
Operation Stage					
11	Hydrometeor	Water flow at the new intake weir in the Laleia river is monitored periodically by visual observation. Implement construction to prevent potential calamity, if such calamity will be expected in the Laleia river.	District Agr.	MAF	Administration cost
13	Involuntary resettlement	Coordinate and manage grievances on land acquisition in discussion, coordinating with the National Directorate of Land, Property and Cadastral Services.	District Agr., Local Gov.	MAF	Administration cost
19	Social institutions	Coordinate and manage grievances on imbalance between Laleia and Vemasse sub-district, when necessary.	District Agr., Local Gov.	MAF	Administration cost
20	Misdistribution of benefits and damages	Monitor irrigation water supply to each irrigation block periodically. Coordinate and manage grievances on distribution of irrigation water, when necessary.	District Agr., Local Gov.	MAF	Administration cost
21	Local conflicts of interest	Monitor irrigation water supply to each irrigation block periodically. Coordinate and manage grievances on distribution of irrigation water, when necessary.	District Agr., Local Gov.	MAF	Administration cost
				Total Cost	To be estimated

The additional cost for the mitigation measures shall be covered principally by the implementing organization indicated in the table. The cost is estimated as not very high and generally included in the project cost for construction or in the general budget of the government.

1-4-10 Monitoring Plan

The monitoring on the environmental and social impacts shall be carried out for the purpose of the early identification and mitigation of the adverse impacts of the Project. The monitoring plan in construction stage and operation stage is shown in the following table.

Table 1-21 Monitoring Plan during Construction Stage and Operation Stage

Item	Indicator	Method	Site	Frequency	Responsible Organization
Construction Stage					
Air pollution	Dust	Visual observation	All construction site	Monthly	Contractor
Water pollution	Turbidity	Visual observation	Laleia river	Monthly	Contractor
Waste	Volume of waste	Visual observation	All construction site	Monthly	Contractor
Soil pollution	Contamination	Visual observation	All construction site	Monthly	Contractor
Noise and vibration	Noise level	Physical observation	All construction site	Monthly	Contractor
Involuntary resettlement	No, of grievances	Grievance mechanism	All project area	Monthly	District Agri. Local Gov.
Land use and utilization of local resources	No, of grievances	Record of grievances	All project area	Monthly	District Agri., Local Gov.
Water use	No, of grievances	Record of grievances	All project area	Monthly	District Agri., Local Gov.
Existing social infrastructures and services	No, of grievances	Record of grievances	All project area	Monthly	District Agri., Local Gov.
Social capital and institutions	No, of grievances	Record of grievances	All project area	Monthly	District Agri., Local Gov.
Misdistribution of benefits and damages	No, of grievances	Record of grievances	All project area	Monthly	District Agri., Local Gov.
Local conflicts of interest	No, of grievances	Record of grievances	All project area	Monthly	District Agri., Local Gov.
Accidents	No, and extent of accidents	Record of accidents	All project area	Monthly	Contractor
Operation Stage					
Hydrometeor	River flow of the Laleia river	Visual observation	Intake weir site	Quarterly	District Agri.
Involuntary resettlement	No. of grievances	Record of grievances	All project area	Quarterly	District Agri., Local Gov.
Social institutions	No. of grievances	Record of grievances	All project area	Quarterly	District Agri., Local Gov.
Misdistribution of benefits and damages	Record of irrigation water supply No. of grievances	Record of irrigation water supply Record of grievances	All project area	Quarterly	District Agri., Local Gov.
Local conflicts of interest	Record of irrigation water supply No. of grievances	Record of irrigation water supply Record of grievances	All project area	Quarterly	District Agri., Local Gov.

Note: District Agri.: District agriculture offices of Manatuto and Baucau districts
Local Gov.: Sub-district administrations of Laleia and Vemasse sub-districts

The monitoring forms were proposed for the construction stage and operation stage separately, as attached. The responsible organizations shall fill the forms and submit them to the MAF in accordance with the instructions on the forms. The MAF shall check the forms, and then order re-investigation or take mitigation measures, when necessary.

The responsible implementing and supervising organizations for monitoring are arranged to ensure the

proposed mitigation measures, as shown in the following Figure 1-19. The MAF is the executing agency responsible for the implementation of the overall EMP. The National Directorate of Irrigation and Water Management shall provide staffs to participate in the project implementation as a group for project management. The group will supervise the EMP implementation during the construction stage. The group will order the contractor, local administrations and district agriculture offices to monitor the relevant environmental issues. The qualified international and national environmental specialists shall support the activities of the group.

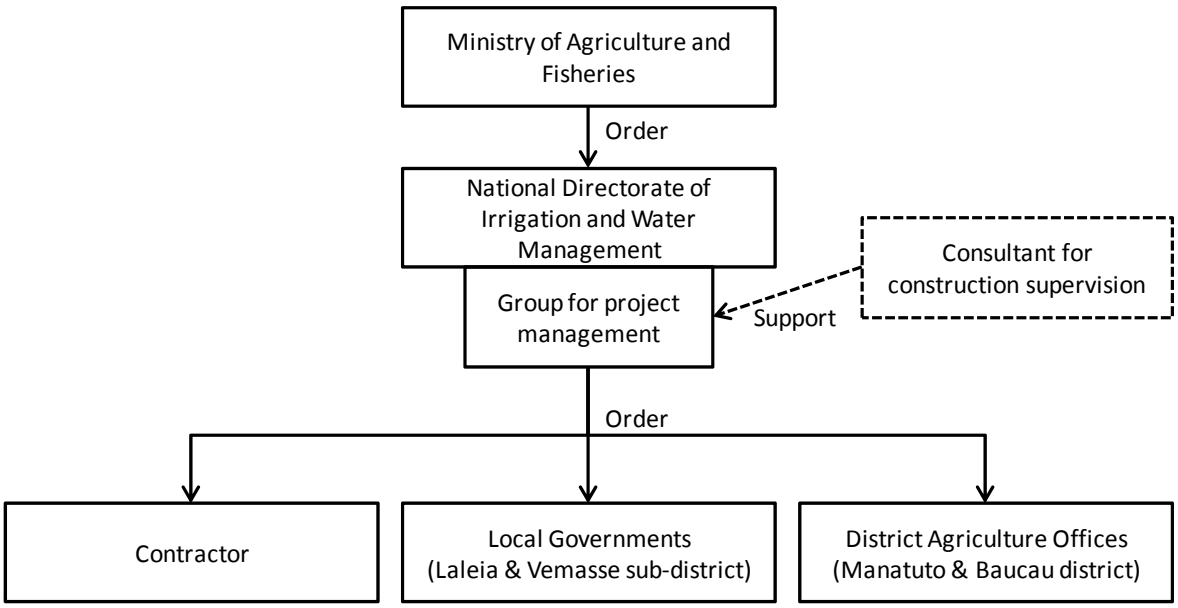


Figure 1-21 Proposed Organization Structure for EMP during the Construction Stage

1-4-11 Consultation with Stakeholders of the Project

During the preparatory survey of the Project, consultation meetings were held with the stakeholders of the project at Laleia and Vemasse sub-district on November 16 and 22, 2012, respectively. The local authorities and beneficiaries participated to the meeting. The MAF staffs and JICA survey team explained the outline of the Project and the participants discussed some important issues, for example, new irrigation water supply and management system, land acquisition for the facilities, and so on. The major comments in these meetings and correspondences are summarized in the following table.

Table 1-22 Major Comments at Public Consultation and their Correspondence

Comments	Correspondence
Public Consultation at Laleia on 16 Nov. 2012	
Statement on coordination of irrigation water allocation in the project area in accordance with local community rules.	Agreed.
Request to leave three existing traditional irrigation canals and each intake facilities in the right side along the Laleia river.	Request to understand that three traditional irrigation schemes will be unified to advance as technical irrigation system in accordance with national policy.
Request to design canal routes not to enter inside field so much like 10 m.	The layout of canals is decided along the edge of fields as much as possible.
Request to implement a traditional ceremony before the commencement of geological survey at the proposed weir site.	Agreed.
Public Consultation at Vemasse on 22 Nov. 2012	
Request to move the alignment stakes along the proposed canals from the middle of rice field to the edge of field.	The stakes were moved.
Request to consider layout of the canals along the edge of field, and not to cross the field.	The layout of canals is decided along the edge of fields as much as possible.
Request to continue internal discussion on land acquisition among the local authorities and land owners.	Agreed.
Request to reduce the total width of main canal and maintenance road from 12 m to 9 m.	The width was minimized in the design by consideration of use of existing roads as maintenance road.

The meetings were held as a kind of kick-off for dialogues of the project implementing body with the local authorities. The local residents generally showed favorable opinions to the project framework, but they requested to reconsider layout and width of the canals. The MAF and the JICA team reply them to prepare final design of the canals taking into consideration of their opinions in this regard. The stakeholders consultation on the Project shall be continued in the course of the project implementation, as necessary.

1-5 Land Acquisition and Involuntary Resettlement

1-5-1 Necessity of Land Acquisition and Involuntary Resettlement

The Project requires some land acquisition for construction of the irrigation facilities, while involuntary resettlement is not expected. The facilities for which the acquirement of private lands are necessary, are listed below.

- Intake weir: Intake weir will be constructed in the upper area of the Laleia River, and the land for the construction of the weir and related facilities is necessary.
- Main and secondary canals: The route of the canals and maintenance roads shall be acquired. The existing canals and roads shall be maximally used for the new irrigation system in order to minimize the land to be transformed from paddy field.
- Meeting Place of WUA: The center of the water users association shall be newly installed in the middle part of the beneficial area.
- Irrigation Water Fee: The irrigation water fee is not paid in cash or in kind in the existing local irrigation system, although farmers provide labor force for maintenance of irrigation facilities.

1-5-2 Legal Framework on Land Acquisition and Involuntary Resettlement

(1) Legal Gap Analysis between Laws in Timor-Leste and the JICA Guidelines

The constitution of the Timor-Leste clearly describes the principle of the right to private property in Section 54, as shown below. However, the land law is not officially published yet in Timor-Leste, although the preparation of the law has been going on.

> Constitution of the Democratic Republic of Timor-Leste
>
> Section 54 (Right to private property)
>
> 1. Every individual has the right to private property and can transfer it during his or her lifetime or on death, in accordance with the law.
> 2. Private property should not be used to the detriment of its social purpose.
> 3. Requisitioning and expropriation of property for public purposes shall only take place following fair compensation in accordance with the law.
> 4. Only national citizens have the right to ownership of land.

Regarding land acquisition and involuntary resettlement, the gap between legal framework of Timor-Leste and the JICA guidelines/WB O.P.4.12 was analyzed as shown in the following table. The legal framework of Timor-Leste is only prescribed in the constitution because the land law has not been resolved yet. There is no significant gap between the principles described in the constitution

and the JICA guidelines/WB O.P.4.12

Table 1-23 Gap Analysis of Land Acquisition and Involuntary Resettlement

No.	JICA Guidelines and WB O.P.4,12	Lows of RDTL	Gap
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA Guideline)	Constitution 54 (2)	No gap with the constitution.
2.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL)	Constitution 54 (2)	No gap with the constitution.
3.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL)	Constitution 54 (3)	No gap with the constitution.
4.	Compensation must be based on the full replacement cost as much as possible. (JICA GL)	Constitution 54 (3)	No gap the constitution.
5.	Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL)	Constitution 54 (3)	No gap with the constitution.
6.	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL)	Constitution 54 (3)	No gap with the constitution.
7.	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. (JICA GL)	Constitution 54 (3)	No gap with the constitution.
8.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people. (JICA GL)	Constitution 54 (3)	No gap with the constitution.
9.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans. (JICA GL)	Constitution 54 (3)	No gap with the constitution.
10.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities. (JICA GL)	Constitution 54 (2)	No gap with the constitution.
11.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6)	Constitution 54 (2)	No gap with the constitution.
12.	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15)	Constitution 54 (2)	No gap with the constitution.
13.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11)	Constitution 54 (3)	No gap with the constitution.
14.	Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para.6)	Constitution 54 (3)	No gap with the constitution.
15.	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP4.12 Para.8)	Constitution 54 (3)	No gap with the constitution.
16.	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP4.12 Para.25)	Constitution 54 (3)	No gap with the constitution.

(2) Analysis of Land Acquisition in this Project

In case of the land acquisition by the national government authority, the land acquisition is involuntary and compensation and assistance shall be given under the JICA guidelines. However, the land registration books and cadastral maps were lost during the independence conflict, and the traditional

land users are recognized in rural areas in Timor-Leste. The land acquisition in public works is usually implemented by voluntary land donation under local custom after explanations to local people by the government agencies. Consequently, it is analyzed whether the land acquisition in the project is categorized into the voluntary resettlement and land donation described in the WB O.P.4.12.

"Voluntary resettlement" refers to any resettlement not attributable to eminent domain or other forms of land acquisition backed by the powers of the state. The operative principles in voluntary resettlement are "informed consent" and "power of choice". Regarding power of choice, which means that the people involved have the option to agree or disagree with the land acquisition, without adverse consequences imposed formally or informally by the state. The several public consultations were held among MAF, local administrations and residents, and consensus on donation of farmland is generally formulated at this preparatory survey stage. The main reason of this agreement is that the incremental production of rice by improvement of yield and cropping intensity under proposed irrigation system is much higher than the loss of rice caused by the decrease of farmland area. The result of analysis on "informed consent", which means that the people involved are fully knowledgeable about the project and its implications and consequences and freely agree to participate in the project, is shown in the following table.

Table 1-24 Criteria on Informed Consent

	Criteria	Result of analysis
1	The infrastructure must not be site specific.	The final design of the facilities will be prepared in the detailed design stage, and the modification is still possible reflecting opinions of residents.
2	The impacts must be minor, that is, involve no more than 10 percent of the area of any holding and require no physical relocation.	Total of 321 land owners will be potentially affected by the project, but the land area to be acquired is less than 10 % of their own land area (except the forest area). The resettlement is not anticipated.
3	The land required to meet technical project criteria must be identified by the affected community, not by line agencies or project authorities (nonetheless, technical authorities can help ensure that the land is appropriate for project purposes and that the project will produce no health or environmental safety hazards).	In several stakeholder meetings, the residents understood the detailed information of the project and agreed the framework.
4	The land in question must be free of squatters, encroachers, or other claims or encumbrances.	It was confirmed that there is no squatters or encroachers in the project area.
5	Verification (for example, notarized or witnessed statements) of the voluntary nature of land donations must be obtained from each person donating land.	The list of land owners to be affected was prepared already, and the agreements of voluntary land donations will be signed soon.
6	If any loss of income or physical displacement is envisaged, verification of voluntary acceptance of community-devised mitigatory measures must be obtained from those expected to be adversely affected.	The MAF already explained the preparation of alternative land to a land owner who will lose 0.5 ha (more than 10% of total land) of farmland, and the land owner agreed to the compensation.
7	If community services are to be provided under the project, land title must be vested in the community, or appropriate guarantees of public access to services must be given by the private titleholder.	As this project is rehabilitation of the existing irrigation systems, which all the local residents use. Therefore, public access to the irrigation service is guaranteed.
8	Grievance mechanisms must be available.	The grievance mechanisms are planned to be established for the time being.

(WB Involuntary Resettlement Sourcebook, p22-25)

On the other hand, the compensation for land acquisition might have the following risks.

- Low implementation capacity of the MAF, which has little experience of compensation to land
- Difficult persuasion for the MAF, which declared that no compensation was planned
- Delay of the Project implementation due to confusion of compensation to land

(3) Policy of Land Acquisition in this Project

As a conclusion of the analysis, the land acquisition in this Project is judged as voluntary land donations and not necessary to be compensated, because the 8 criteria of the informed consent on the voluntary resettlement and land donation described in the WB O.P.23. Further, the land owners recognized that the rice production under the new irrigation system would increase due to the higher yield and cropping intensity. Only a land owner, who is not judged to be voluntary, necessary compensation, will be provided as mentioned in section 1-5-4. The conflict to other landowners who would not be compensated for canal construction would not occur, because the farmer would lose comparatively a large area of farmland near the proposed intake weir.

1-5-3 Scope of Land Acquisition and Involuntary Resettlement

The necessary lands for acquisition for constructing intake facility, extending and expanding main canal and secondary canals and so on in the Project area, were identified as about 19 ha in the field survey. The land owners (or customary and traditional land users) were also identified.

The main canal (upper and middle portion), secondary canals and drainage canals were laid out along the existing canals to minimize the area of land acquisition. The lower portion of the main canal (about 5.5 km) and intake facilities sites needs land acquisition, as shown in the following table. The local residents and land owners showed consent to the plan of the project and land acquisition in the public consultation meetings.

Table 1-25 Scope for Land Acquisition

	Item	Distance	Area	Land Use	Remarks
A	Intake Facility		5,000 m^2 (L) 100,000 m^2 (R)	Farmland (left) Forest (right)	1 owner (L), 4 owners (R); Emergency purpose on the right bank
B	Main Canal	12,334 m	75,700 m^2	Farmland, Potential farmland, Road, House (Government land: 1,390m on left, 5,985m in right)	77 owners

	Item	Distance	Area	Land Use	Remarks
C	Secondary Canal 1	2,400 m		All farmland	30 owners
	Secondary Canal 2	850 m		All farmland	15 owners
	Secondary Canal 3	1,390 m		All farmland	20 owners
	Secondary Canal 4	1,558 m		All farmland or potential farmland	28 owners
	Secondary Canal 5	1,083 m		All farmland	16 owners
	Secondary Canal 6	388 m		All farmland	5 owners
	Secondary Canal 7	522 m		All farmland	7 owners
	Secondary Canal 8	550 m		All farmland	7 owners
	Secondary Canal 9	1,039 m		All farmland	12 owners
	Secondary Canal 10	623 m		All farmland or potential farmland	4 owners
	Secondary Canal 11	100 m		All farmland	9 owners
	Secondary Canal 12	1,330 m		All farmland	29 owners
	Secondary Canal 13	1,316 m		All farmland	6 owners
	Secondary Canal 14	988 m		All farmland	16 owners
	Secondary Canal 15	650 m		All farmland	7 owners
	Secondary Canal 16	665 m		All farmland	11 owners
D	Drainage Canal 1	2,351 m		All farmland, potential farmland, swamp	17 owners
	Drainage Canal 2	1,645 m		All farmland, swamp	3 owners
E	WUA Facility		5,000 m^2	Waste land	1 owner

In addition, trees standing in proposed intake facilities site and upper portion (about 1,090 m) of the main canal will be cut down for the construction. The maximum number of trees in the possible affected area was estimated by the sample survey. The total number of trees in the area was about 7,000, consisting of 1,550 of Ai Kakeu, 3,100 of Ai Haneki 800 of Kulu and 1,550 of Herotak. Most of them are shrubs, and all of them are recognized as public properties by the residents. There is no objection so far against the cutting of trees.

1-5-4 Concrete Plan of Compensation and Support

The land types subjected to be acquired in the Project are forest area, waste land, farmland or residential area. As mentioned in section 1-5-2, the voluntary land donation is a principle in the Project. Only 0.5 ha of the farmland near the proposed intake weir would be compensated as provision of alternative farmland. The MAF already began the discussion with the land owner, and they reached general understanding. If no alternative farmland would be available, the MAF should compensate the lands at the standard value surveyed.

Though the trees in the construction sites can be subjects of compensation, the old trees growing from Indonesian time were recognized as public property, and economically valuable trees are not so many in the area. Therefore, the cash compensation to the trees is judged not to be necessary.

If further impacts will break out, the local administration and the MAF shall survey the negative impacts and seek solutions as reconciliation or cash compensation.

Regarding potential suspension of land use and irrigation water supply during the construction stage, the mitigation measures described in section 1.4.9 shall be taken. The compensation is not planned for them, following the common practice in Timor-Leste.

Table 1-26 Plan of Compensation

No	Type of loss	Entitled persons	Entitlement	Implementation issues/ guideline	Responsible organization
1	Loss of farmland or residential plot	Land owners	Compensation of value of land	Assessment of quantity and quality of land by MAF Confirmation of voluntary land donation Provision of alternative land or cash compensation to a land owner	MAF
2	Loss of trees	Land owners, Owners of trees	Compensation of value of tree	Assessment of quantity and kinds of trees by MAF Confirmation of voluntary donation	MAF
3	Unforeseen impact	Persons concerned to impact	Reconciliation or compensation	Assessment of occurred impacts by local administration and MAF Discussions with persons concerned to the impacts, seeking solutions Payment of cash compensation	MAF Local administration

1-5-5 Grievance Mechanism

The coordination meetings with the government and residents shall be organized to promote people's understandings and cooperation to the Project.

In order to manage the grievances related to lands and other properties, the grievance reception institution, which shall be established by members of NGOs, universities, etc., shall receive grievances from residents and report them to the MAF. The MAF shall play a role of a grievance reception institution before contract with the other organizations. The MAF already began public consultations and discussions with the land owners to mediate disputes on land and property.

1-5-6 Implementation System

The organizations related to the land acquisition in the Project are listed and their roles are summarized below.

- National Directorate of Policy and Planning; Ministry of Agriculture and Fisheries:
  Arrangement of necessary budget for land acquisition
- National Directorate of Irrigation and Water Management; Ministry of Agriculture and Fisheries:
  Survey on land acquisition, Implementation of public consultation meetings, Negotiation with land owners, Estimate of cost, Application of budget, Payment of compensation
- District Agriculture Office of Manatuto and Baucau; Ministry of Agriculture and Fisheries:
  Field works together with National Directorate of Irrigation and Water Management, Field work on land acquisition
- National Directorate of Land, Property and Cadastral Services; Ministry of Justice:
  Institutional assistance on land acquisition
- Sub-district administration of Laleia and Vemasse:
  General administrative arrangement

1-5-7 Implementation Schedule

Although the final layout and design of the facilities shall be determined in the upcoming detailed design stage, the location and area of the lands to be acquired are tentatively surveyed during the preparatory survey. The MAF shall arrange the agreement on voluntary land donation with land owners to be affected, based on this survey result. Also the MAF shall prepare alternative farmland for a landowner near the proposed intake weir site.

During the detailed design stage, the MAF shall prepare final design of the facilities and identified area to be acquired. The MAF shall confirm voluntary land donation with the land owners soon. The MAF also confirm provision of alternative farmland with the landowner near the weir site.

1-5-8 Cost and Resource

As the voluntary land donation is planned in this project, the compensation cost for land is not necessary. The alternative farmland for a landowner shall be prepared from public land without procurement cost. The trees in the construction sites are also not necessary to be compensated in cash due to voluntary donation.

1-5-9 Monitoring System and Monitoring Form

The Ministry of Agriculture and Fisheries shall monitor continuously during the construction stage and operation stage. The officer in charge and relevant extension workers of the District Agriculture Offices shall perform the field works. During the construction stage, the Ministry shall conduct the meetings with the residents to restrain grievances related to land and properties, and instruct the contractor to mitigate any negative impacts on land and properties. The District Agriculture Offices shall report to the National Directorate of Irrigation and Water Management every month. The general method of the monitoring is described in section 1-4-10.

1-5-10 Public Consultation

At the preparatory survey of the Project, public consultation meetings were held at Laleia and Vemasse sub-district on November 16 and 22, 2012, respectively. The local authorities and beneficiaries participated in the meeting. The MAF staffs and JICA survey team explained the outline of the Project and the participants discussed some important issues, for example, new irrigation water supply and management system, land acquisition for the facilities, and so on. The general method of the monitoring is described in section 1-4-11.

The meetings were held as a kind of kick-off for dialogues of the project implementing body with the local authorities. The public consultation on the Project shall be continued in the course of the project implementation, as and when necessary.

CHAPTER 2 CONTENTS OF THE PROJECT

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2-1 Basic Concept of the Project

The proposed Project for Rehabilitation and Improvement of the Buluto Irrigation Scheme aims at achieving the following 3 targets to increase the agricultural production by 2020 in accordance with the Strategic Development Plan of SDP 2011-2030 which is the Overall Goal of agriculture development of the Government of Timor-Leste:

(1) Increase in irrigated paddy field area from 50,000ha to 70,000ha,
(2) Increase in the paddy yield from 1.43 ton/ha to 2.02 ton/ha (2030)
(3) Decrease in the storage loss at the farm level from 20% to 5% (2030).

As a part of the achievement of the 3 targets, the Government proposed Projects in 9 areas including the Project in Buluto. Therefore, the implementation of the Project is in line with the development policy of the Government. Three projects among the remaining projects are in progress, which are implemented by the local fund in Calaulun, Beikala and Raivere.

The objective of the proposed Project is to contribute for enhancing the livelihood level of the beneficiary farmers and to increase the self sufficiency of the country by the rehabilitation and improvement of the the Buluto Irrigation Scheme and by the implementation of soft component for strengthening of water users association so as to increase the area and volume of rice production.

The effect of the production increase of the Project is considerable, since the Project is a large scale project in Timor-Leste. By means of completion of the headworks by the Project, the rice production is increased by stable supply of irrigation water in the rainy season, and expansion of the paddy field area in the dry season, when the market price of rice is high.

In order to accomplish the overall goal and objectives of the Project, the stable intake and supply of irrigation water are inevitable considering the climate change (extraordinary flood, etc.). Therefore, the new development and improvement of the infrastructure as a hardware component, and improvement of operation and maintenance as a soft component are prerequisite for input, activities and output of the Project as described below.

Required Input:

1) Procurement of machinery/equipment and materials necessary for rehabilitation and improvement of the facilities, and implementation of the work,
2) Dispatching of human resources (engineers) accompanied with the above mentioned activities and
3) Dispatching of Japanese engineers to implement the soft component.

Required Activities:

1) Conducting study for detailed design required for the above mentioned procurement and work and
2) Implementation of the software component in regard to capacity development for operation and maintenance of the facilities.

Expected Output:

1) Improvement of rice productivity in the rainy and the dry seasons through the development of the irrigation facilities in the Buluto Irrigation Scheme and
2) Enhancement of livelihood of the beneficiary farmers by increasing the rice production.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Policies

In formulating the Project, the position, effects, technical and economic feasibility, and relevance of the Japanese Grant Aid system towards the implementation of this Project are to be verified, and thereby the essential and optimum design of the planned facilities is provided for obtaining proper outputs of the Project.

The design of the facilities consist of the design of headworks including various gates to take stable water from the water resource (Laleia river), and the design of the main canal and secondary canals to convey and distribute the irrigation water to the paddy field of 780 ha, and the design of other facilities such as improvement of 2 drainage canals to drain local rain water, revetment along Vemasse river to protect main canal, and meeting facility for WUA. These are also included in the design policy.

An intake gate was constructed at the proposed site for new head works at the right bank of the Laleia river. However, this old intake was collapsed by floods and has not been used. The old main canal which connects with this old intake and starts from the immediate downstream of the intake, is used only in the rainy season, since this existing main canal has only limited flow section due to high elevation of the canal bed and sediment deposit by slope failure.

The scope of works for recovering the functions of the irrigation system, which was requested by the Government of Timor-Leste has been revised and specified clearly as mentioned in Table 2-1. There is additional description for the following facilities;

- Sediment trap and gate operation house for head works related facilities and
- A meeting facility of Water Users' Association (WUA), revetment and demonstration farm for the canal related facilities.

Table 2-1 Project Components in the Request

Request (According to M/M)	This Preparatory Survey Report
1. Intake facilities accompanied by fixed weir	1. Intake facilities accompanied by fixed weir, sediment trap and gate operation house
2. Construction of diversion gate, drainage work, sediment flush gate and other related structures, main and secondary irrigation canal	2. Construction of diversion gate, drainage work, sediment flush gate, other related structures, meeting facilities for WUA, revetment on the right bank, demonstration farm, and main and secondary irrigation canal
3. Construction of drainage canal	3. Same as the left
4. Construction of operation and maintenance road	4. Same as the left
5. Soft component for strengthening of WUA	5. Same as the left

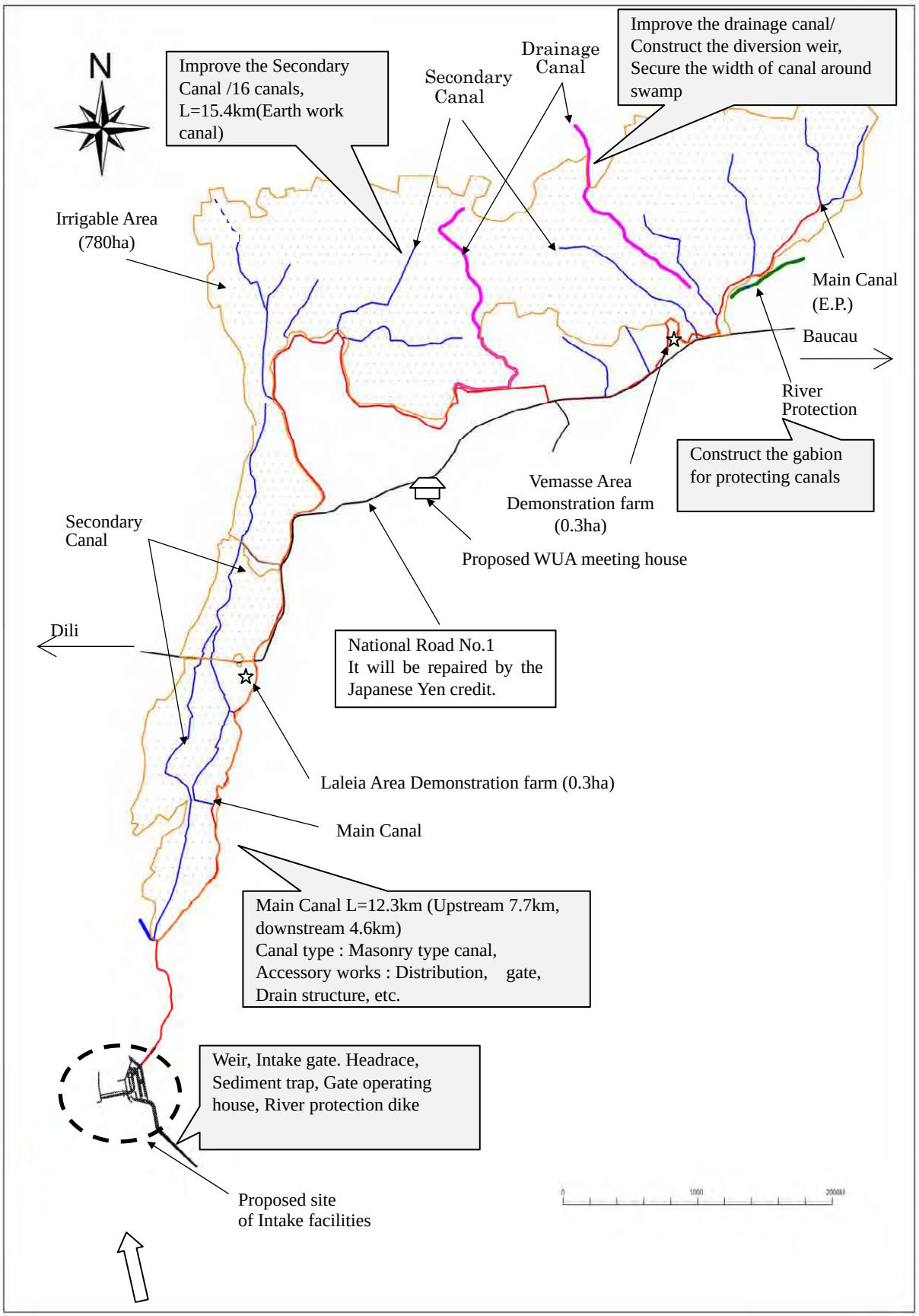


Figure 2-1 General Plan

(2) Policies on Natural Environmental Conditions

The following policies are applicable to the natural environmental conditions as required by the facility plan.

1) Design Flood Discharge

The discharge observation data are available for only 10 years for Laleia river during the time of Indonesia with insufficient reliability. The flood discharge was, therefore, estimated by the flood mark survey of the local people in the vicinity and the interview survey with the results of the river profile and cross section survey during the field survey. The calculation results reveal that the design flood discharge was estimated at 1,500 m^3/s with 100-years probability.

2) Design Drought Discharge

The drought discharge in the dry season was estimated with 5-years probability of occurrence in order to estimate the irrigated area in the dry season and the rainy season.

According to the estimate mentioned above, in the beginning of December when the land preparation starts, sufficient discharge was confirmed in the river to irrigate entire 780 ha of crop cultivation in the rainy season, while, a half of the entire area (390ha) is possible to be irrigated in the dry season.

3) Geology of the Proposed Area of Intake Facilities

According to the results of the field investigation by the use of an excavator, the sediment deposit in the right and left banks with a depth of 2 to 3meters from the ground surface consists of silty sand (finer grain is more) and the layer deeper than 2 to 3meters consists of sand and gravel mixed with boulders. The foundation ground of the river bed with a depth of 2 meters from the ground surface consists of sand (finer grain is less) and the layer deeper than 2 meters consists of sand and gravel mixed with boulders.

The grain size distribution of sediment deposit at the scouring depth during flood was confirmed by the grain size analysis. The results of the analysis revealed that the sediment deposit of the whole area of the river bed with a depth of 2 to 3 meters from the ground surface consists of sand and gravel with grain sizes of 20 mm or less, and there are possibility of scouring up to the depth of 2 meters during flood flow, and it is required to pay attention to piping phenomena at the foundation of the river bed protection. However, the deposit with a depth of 3 meters from the riverbed consists of sand and gravel mixed with boulders which is expected to have sufficient strength considering the depth of the foundation of structures. On the other hand, the coefficient of permeability of the foundation ground with a depth of 3 to 4 meters from the riverbed surface was measured as high as $2f\ t^{-3}$ m/s which requires attention to control the permeability of the foundation ground, and needs to be considered in the design policy.

(3) Condition of Farm Management and Irrigation Facilities

The main purpose of the Project under consideration is improvement and upgrading of the function of the Buluto Irrigation Scheme through new construction of intake facilities and improvement and extension of the irrigation canal, and enhancement of livelihood by the improvement of farm management environment through stable intake of irrigation water. The Project will contribute to the national target for the food self-sufficiency by achieving the stable rice production in the rainy season, and the production in the dry season in half area of the benefitted Project area.

In order to assist the increase in rice production, the guidance for farm management by the extension officers is expected to be enforced. The on-going improvement of the farm management through ICM (Integrated Crop Management) is in progress in 30% of the Project area, and there is a 20% increase in the rice production. The proposed Project aims to increase the productivity further through expansion of the area covered by the improved cultivation method, i.e. ICM. In addition, the soft component of the Project is planned to be conducted to transfer techniques related to the effective operation and maintenance of the irrigation water management facilities.

(4) Policies on Socio Economic Conditions

The implementation of the improvement of the the Buluto Irrigation Scheme is deemed to bring positive impact on the local economy through the production increase and associated enhancement of the livelihood of the beneficiaries. The proposed Project is expected to distribute equal benefit to most of the farm families, because large land ownership is not observed in the Project area, and most of the benefit will be shared by the farm families.

The Project under consideration does not aim at significant changes in the present life style and customary practice of the farmers, but aims at increasing the rice production and livelihood enhancement by the introduction of the modern irrigation system and improvement of the existing facilities for the beneficiaries of the Buluto system area which still practice unstable rice cultivation with a low production. It is judged from the view point of gender that the incremental labor force is not distributed only to women, because it is a general practice in the area to carry out the work both by men and women for the community, domestic and agricultural works.

(5) Policies on the Situations of Construction and Procurement

1) Laws and Regulations

As to labor conditions including minimum wages and labor hours, they are based on the articles of the related laws and regulations of Timor-Leste.

2) Standards

Since the standards of construction and design management for the construction work have not yet

been consolidated in Timor-Leste, the specifications, quality, testing control of machinery, equipment procurement and construction work are to be founded based on ISO and JIS.

3) Construction Situations

Currently, the local contractors managed by Timores are found in Timor-Leste (5-6 medium class), and some construction firms including Australian has been established by foreign capitals. As to local constructors, most of them are small scale, and they are engaged in revetment works, roads, river improvement, building, etc. mainly in and around Dili. They own construction machineries and equipment to some extent and are possible to be engaged in works such as earth works, concrete works, etc. which do not require high level techniques. Therefore, it is judged to be possible for these contractors to be engaged in the implementation of the proposed Project as a sub-contractor under adequate quality control carried out by the Japanese contractor as a prime contractor.

4) Procurement Situations

According to the study on the availability of local construction firms, currently, several projects are under planning and implementation, which include improvement plan of National Road No.1 by the Japanese Yen credit and 3 irrigation projects financed by the Government. Since most of the materials and equipment are imported and procured by the international contract, there is an escalation of the construction cost and shortage of number of labors and technicians. In respect to construction equipment, concrete plant, etc. as required, they shall be imported from Japan or other advanced countries in the vicinity.

(6) Policies on the Utilization of Local Construction Firms

In the cases of works including earth work, wet masonry, gabion, etc., which do not require high level techniques, it is possible to make use of local construction firms in consideration of its scale and degree of difficulty of the works.

(7) Policies towards Management, Operation and Maintenance

The management, operation and maintenance have not yet been completed in the proposed Project. In parallel with the commencement of the construction work, it is planned that training of the beneficiary farmers will be executed to establish of WUA and operation & maintenance of the irrigation facilities under the guidance of the Directorate of Irrigation Water Management. In the soft component plan of the proposed Project, it is planned to dispatch instructors to assist for the establishment and activities of WUA. The place of the training will be the WUA meeting facility to be constructed by the Project

Key points of the management and operation & maintenance are enumerated below:

- In order to carry out the effective management, operation and maintenance of the irrigation facilities to be constructed and improved by the Project, the Project assists the National Department of Irrigation Water Management for the establishment of WUA.
- Aiming at sustainable use of irrigation facilities to be constructed by the Project, the Project will conduct training to the members of the WUA for studying and understanding of the operation and maintenance techniques.
- Pertinent method of water management such as operation of gates should be trained so that the facilities can be used effectively by the farmers.

The soft component is provided for realizing these capacity improvement targets as a supporting activity, and assisting to obtain required knowledge and techniques and to sustain operation and maintenance.

(8) Policies on the Establishment of the Grade of the Planned Facilities

The facilities of the Buluto Irrigation Scheme shall be designed by adopting the following parameters based on natural and environmental conditions and the planned scale of the target area:

- Design water intake: 2.40 m^3/s (maximum intake discharge)
- Design flood discharge: 1,500 m^3/s (flood discharge with 100-years probability)

The planned facilities are mainly those constructed inside and outside of the river. Since Laleia river is characterized by its steep river bed gradient of I=1/200 with scattered boulder with a maximum size of 50 cm over the riverbed, risk that facilities installed inside the river-bed are damaged by abrasion and impact with bounding bolder is fully taken into consideration. Since the planned flood discharge of 1,500 m^3/s is a higher value, it is required to design structures with sufficient stability against enormous flood energy considering the sustainable structure.

In regard to the facilities to be constructed outside the river such as canal, the same policy of repairing and rehabilitation works is applied considering that the possibility of proper maintenance by the local people in Timor-Leste can lead to long-term operation of functions of the facilities.

In conclusion, in the facility planning, the structures are designed with sufficient durability by assessing the influence of floods and bounding boulder and permitting some degree of damages. These damages will be managed by proper maintenance, and adopting the grade of the planned facilities by assessing shapes of the structures so that it can alleviate the action force of flood energy or impact of boulders.

(9) Policies concerning Construction and Procurement Method and Construction Period

1) Construction Work of the Buluto Irrigating System

In this Project, the construction works inside the river stream include new headworks, scouring sluice, intake gate structure, revetment work, etc., and the works outside the river stream include

sediment trap, headrace channel, main canal, secondary canal, drainage canal, WUA meeting facility (building), etc.

The procurement and setting for batcher plant (concrete plant) is scheduled to be carried out in June-July after arrival of the plant at the site. The other equipment to be procured in Japan such as bulldozer, backhoe, dump track, agitator truck and concrete pump truck shall be planned under the policy considering the location and timing of the procurement including sufficient time for shipment and sea transport.

The proposed construction progress of the main work which follows after the temporary work shall be determined considering relationship between the mutual works, security, efficiency, technical standard of local workers and the following items:

- The gravity drainage shall be studied after investigation of the river flow so as not to rely on the pump drainage to the extent possible. Particular attention must be paid to the underground drainage from drainage catchment basin with an area of 3 km^2 in the right bank.
- The rainfall in Timor-Leste is affected by El Nino phenomena with a high rainfall in a cycle of once in 4 to 5 years. In such a year, the rainy season begins in September to November compared to December in the normal year. Attention is required to minimize the flood damage and work plan for concrete structure.
- The construction schedule of the irrigation facilities shall be planned with due attention to the cropping schedule which start irrigation for land preparation in December to January and cultivation lasts up to April.
- In respect to the construction of the drainage canal, the canal widening work is located at the swampy area at the downstream end of the drainage. The canal work in December when the soil is most dry and immediately before the rainy season is preferable for the work to the extent possible.

2) Method of Procurement

The reinforcement steel bar, sand, gravel, stone, etc. these are available in market in Timor-Leste will be locally procured for use in this Project. The conventional construction machinery such as back-hoes, bulldozers, dump trucks etc. are difficult to be procured locally in Timor-Leste and are costly, if they are imported from a third country in the vicinity. Accordingly, the machinery may be procured from Japan.

3) Determination of Construction Period

The construction period is to be determined by examining the following conditions:

- A temporary construction road of a length with 2.3 km is to be constructed to access to the proposed base camp located at the right bank side of the proposed head works. This temporary road shall be paved by gravel considering the traffic in the rainy season. After

completion of the construction work, this road will remain as the access road to the headworks as well as the operation and maintenance road for the main canal.

- Since it is difficult for the headworks with a concrete volume of little more than 10,000m^3 to be completed in one dry season, this concrete work is planned to be constructed in two dry seasons in accordance with the construction plan. Mainly the intake structures, sediment trap, headrace, scouring sluice are scheduled to be constructed in the first dry season and fixed weir and flood protection dike are scheduled to be constructed in the 2nd dry season.
- The concrete production capacity is estimated as follows:
  - ✧ Mixing volume: 1.0m^3 per a mixing
  - ✧ Mixing volume: 6.0 m^3/hr
  - ✧ Mixing volume: 60 m^3/day

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

2-2-2-1 Irrigation Planning

(1) Irrigation Area

The gross irrigation area was estimated as 821 ha based on the results of the field reconnaissance survey. The net irrigation area was estimated as 780 ha, after deducting the areas for canals, roads and paddy field dikes (estimated at 5% in total) from the above gross area. The left bank irrigated area of 40 ha covered by Wenoren traditional irrigation system will be irrigated by the Project.

(2) Irrigation Water Requirement

The irrigation water requirement was estimated under the following conditions:

a) Beneficiary Area: 780 ha of the paddy fields in the rainy season, and 390 ha in the dry season which do not include 40 ha covered by the Wenoren traditional irrigation system

b) Effective Rainfall: 80 % of the daily rainfall (disregard the rainfall of less than 5 and more than 250 mm)

c) Irrigation Efficiency: 0.544

d) Canal conveyance efficiency: Main canal (85%), Secondary & Tertiary (80%) and Field application (80%)

e) Land preparation water: 300mm

f) Irrigation after maximum tillering and drainage: 50mm x 2 times

g) Field Percolation: 3.0 mm/day in upper Laleia and 4.5 mm/day in lower Vamasse

The field test for the water requirement rate was carried out in the upper Laleia and the lower Vemasse

in February and March, 2013. The results of the measurement reveal that the rates were 11 to 12 mm/day. Considering the results of the water requirement calculation and the grain size analysis of soils in the paddy fields, the field percolation rates were estimated as 3 mm/day for the upper Laleia and 4.5 mm/day for the lower Vemasse which was more sandy soil (larger grain size) than soils in the upper Laleia.

The gross water requirement is estimated as tabulated below, under no rainfall condition.

Table 2-2 Gross Water Requirement (Maximum) Unit ; lit/sec/ha

Field Percolation	Rainy Season	Dry Season
3.0mm/day	2.39	2.60
4.5mm/day	2.55	2.79

The irrigation block diagram is shown in Figure 2-2. The maximum water requirement was estimated as 1.908 m^3/sec based on the diagram. The gross water requirement for the left bank benefitted area (40ha) was estimated as 0.112 m^3/sec at the maximum under the cropping intensity of 100 %. The left bank benefit area of the existing 40 ha is included in the Project, since this area will be disturbed by the construction of the headworks.

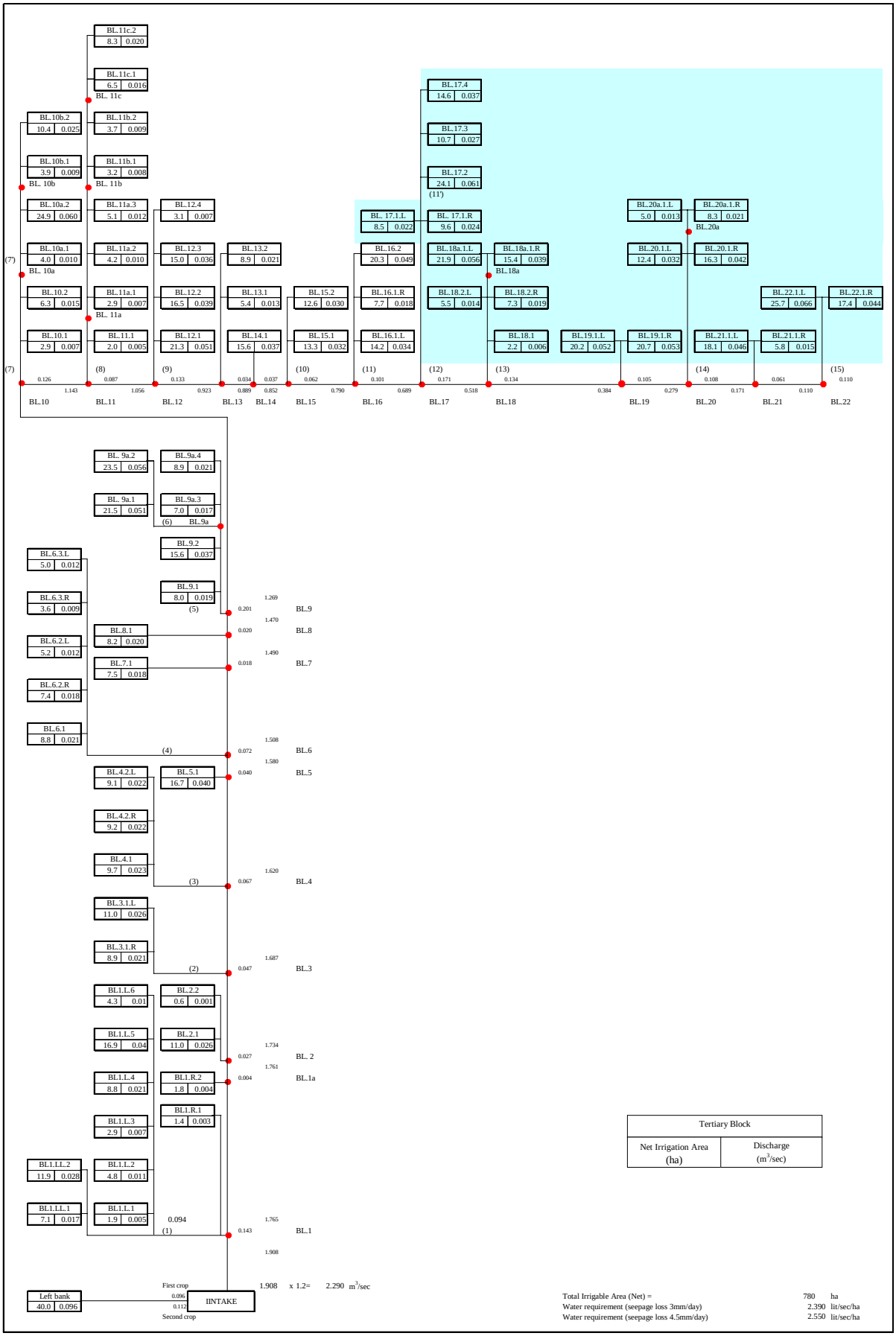


Figure 2-2 Irrigation Block Diagram

2-2-2-2 Design Flood Discharge

(1) Calculation Method

There is no discharge measurement station available along the Laleia river. The design flood discharge at the head works is estimated as described below:

i) Estimation by Rational Formula using daily rainfall
ii) Estimation by Flood Mark along the river

(2) Estimation by Rational Formula Using Daily Rainfall

The most reliable long term rainfall observation record in Timor-Leste is available at Dili airport for 25 years from 1977 to 2012 (no record for the period of 1992-2002). In general, the rainfall data for 40 years are required for the probability analysis of 100 years. However, only the data available for 25 years at Dili were used for the 100 years design discharge. The records of the annual maximum daily rainfalls are listed in Table 2-3.

Table 2-3 Annual Maximum Daily Rainfall (Dili Station)

Year	Rainfall (mm/day)	Year	Rainfall (mm/day)	Year	Rainfall (mm/day)
1977	80	1986	52	2005	113
1978	113	1987	45	2006	69.4
1979	58	1988	60	2007	69.4
1980	85	1989	40	2008	81.6
1981	102	1990	51	2009	34.6
1982	58	1991	46	2010	140
1983	61	2003	54.2	2011	48
1984	78	2004	127	2012	96
1985	72				

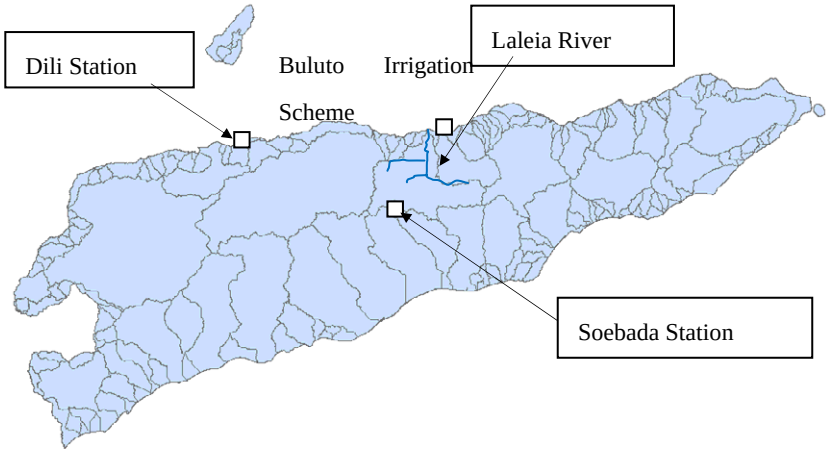


Figure 2-3 Location of Observation Stations

The daily rainfall for each probable year of occurrence is shown in Table 2-4 in accordance with the Gumbel distribution function.

Table 2-4 Probable Rainfall Intensity (mm/day)

Probable Year	Dili Station	Soebada Station*[1]
2	74.6	82.1
5	97.5	107.2
10	116.1	127.7
25	139.6	153.6
50	157.1	172.8
100	174.5	191.9

Note: Rainfall intensity at Soebada station which is near the Project area is 10% higher than that at Dili Station according to the available data for 3 years (2010-2012)*[1]. The data at Soebada Station is obtained by application of 10% higher rainfall than the data at Dili.

The design flood discharge is calculated by the rainfall intensity within the concentration time of drainage by the following Mononobe formula. The concentration time of the drainage is obtained from the calculation of the travel time of flood for each river basin. The concentration time of 3.17 hours were found from 0.84+0.45+0.73+1.15 for catchment basins No. 4-7-8-9 as shown in Table 2-6.

$$I = \left(\frac{R_{24}}{24}\right)\left(\frac{24}{t}\right)^{2/3}$$

where: I: Rainfall intensity (mm/hr)

R_{24}: Design daily rainfall (mm/day)

T: Rainfall period (hr)

Table 2-5 Tributary, Catchment and Slope of the Basin

Basin	River Length (m)	Catchment (km^2)	Average Slope of Catchment (%)
1	7,152	55	22
2	12,940	80	20
3	6,264	51	27
4	12,636	122	22
5	717	33	33
6	8,615	33	26
7	6,366	44	28
8	9,740	30	19
9	16,815	89	17

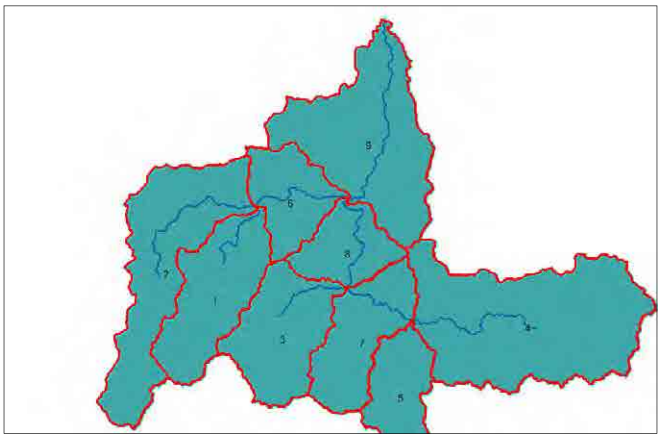


Figure 2-4 Tributaries of Laleia River

Table 2-6 Concentration Time of Drainage for Each Tributary

Basin No.	T_c（hr）
1	0.54
2	0.89
3	0.45
4	**0.84**
5	0.08
6	0.59
7	**0.45**
8	**0.73**
9	**1.15**

T_c: Concentration time of drainage

Concentration time of drainage can be obtained from the following equation:

$$t_c = 0.0078\,(L)^{0.77}\,S^{-0.385}$$

where:

t_c = Concentration time of drainage（minutes）

L = River length（ft）

S = Slope gradient of the catchment area（ft/ft）

Table 2-7 Results of the Concentration Time of Drainage

Tributary	L (feet)	L (m)	S	tc (min)	**tc (hr)**
1	23,465	7152	22	32.4	**0.54**
2	42,454	12,940	20	53.1	**0.89**
3	20,551	6,264	27	27	**0.45**
4	41,457	12,636	22	50.2	**0.84**
5	2,352	717	33	4.7	**0.08**
6	28,264	8,615	26	35.1	**0.59**
7	20,886	6,366	28	27	**0.45**
8	31,955	9,740	19	43.5	**0.73**
9	55,167	16,815	17	69.1	**1.15**

The rainfall intensity in the concentration time of drainage was estimated as 30.9mm/hr (refer to Table 2-8) by the table for the rainfall intensity for probable year in Dili. The flood discharge was estimated as 1,170 m^3/sec by the following rational formula.

$$Q = \frac{1}{3.6} \times C \times I \times A$$

where: Q: Discharge（m^3/sec）

C: Runoff Coefficient（0.25 according to Table 2-9 for ASCE Runoff Coefficient for Various Land Uses）

I: Rainfall intensity for the concentration time of drainage（mm/hr）

A: Catchment area（km^2）

$$Q = \frac{1}{3.6} \times C \times I \times A = \frac{1}{3.6} \times 0.25 \times (30.9 \times 1.1) \times 497 = 1{,}173 m^3/\sec$$

As mentioned in the foot note of Table 2-4, the probable rainfall intensity at Soebada in Buluto is 10% higher than that that of the Dili station. Thus, the data of Soebada (Deli + 10%) is used for the Project.

Table 2-8 Concentration Time of Drainage - Rainfall Intensity (Dili Station)

Time （hr）	Rainfall Intensity (mm/hr.)					
	2 years	5 years	10 years	25 years	50 years	100 years
0.1	149.2	194.8	232.0	279.1	314.0	348.9
0.2	94.0	122.7	146.2	175.8	197.8	219.8
0.3	71.7	93.7	111.6	134.2	151.0	167.7
0.3	59.2	77.3	92.1	110.8	124.6	138.5
0.4	51.0	66.6	79.4	95.5	107.4	119.3
0.5	45.2	59.0	70.3	84.5	95.1	105.7
0.6	40.8	53.2	63.4	76.3	85.8	95.3
0.7	37.3	48.7	58.0	69.8	78.5	87.2
0.8	34.5	45.0	53.6	64.5	72.6	80.6
0.8	32.1	42.0	50.0	60.1	67.6	75.2
0.9	30.2	39.4	46.9	56.4	63.5	70.5
1.0	28.5	37.2	44.3	53.3	59.9	66.6
1.1	27.0	35.2	42.0	50.5	56.8	63.1
1.2	25.7	33.5	39.9	48.0	54.1	60.1
1.3	24.5	32.0	38.2	45.9	51.6	57.4
1.3	23.5	30.7	36.5	44.0	49.5	54.9
1.4	22.6	29.5	35.1	42.2	47.5	52.8
1.5	21.7	28.4	33.8	40.6	45.7	50.8
1.6	21.0	27.4	32.6	39.2	44.1	49.0
1.7	20.2	26.4	31.5	37.9	42.6	47.4
1.8	19.6	25.6	30.5	36.7	41.3	45.8
1.8	19.0	24.8	29.6	35.5	40.0	44.4
1.9	18.4	24.1	28.7	34.5	38.8	43.1
2.0	17.9	23.4	27.9	33.5	37.7	41.9
2.1	17.4	22.8	27.1	32.6	36.7	40.8
2.2	17.0	22.2	26.4	31.8	35.8	39.8
2.3	16.6	21.6	25.8	31.0	34.9	38.8
2.3	16.2	21.1	25.2	30.3	34.1	37.8
2.4	15.8	20.6	24.6	29.6	33.3	37.0
2.5	15.5	20.2	24.0	28.9	32.5	36.1
2.6	15.1	19.7	23.5	28.3	31.8	35.4
2.7	14.8	19.3	23.0	27.7	31.2	34.6
2.8	14.5	18.9	22.6	27.1	30.5	33.9
2.8	14.2	18.6	22.1	26.6	29.9	33.2
2.9	13.9	18.2	21.7	26.1	29.3	32.6
3.0	13.7	17.9	21.3	25.6	28.8	32.0
3.1	13.4	17.5	20.9	25.1	28.3	31.4
3.2	13.2	17.2	20.5	24.7	27.8	***30.9***
3.3	13.0	16.9	20.2	24.3	27.3	30.3
3.3	12.8	16.7	19.8	23.9	26.8	29.8
3.4	12.5	16.4	19.5	23.5	26.4	29.3
3.5	12.3	16.1	19.2	23.1	26.0	28.9
3.6	12.2	15.9	18.9	22.7	25.6	28.4
3.7	12.0	15.6	18.6	22.4	25.2	28.0
3.8	11.8	15.4	18.3	22.1	24.8	27.6
3.8	11.6	15.2	18.1	21.7	24.5	27.2
3.9	11.5	15.0	17.8	21.4	24.1	26.8
4.0	11.3	14.8	17.6	21.1	23.8	26.4
5.0	9.7	12.7	15.1	18.2	20.5	22.8
6.0	8.6	11.3	13.4	16.1	18.1	20.2
10.0	6.1	8.0	9.5	11.5	12.9	14.3
12.0	5.4	7.1	8.4	10.2	11.4	12.7
24.0	3.4	4.5	5.3	6.4	7.2	8.0

Table 2-9 Runoff Coefficient for Land Uses

Land Use	C	Land Use	C
Business:		***Lawns:***	
Downtown areas	0.70 - 0.95	Sandy soil, flat, 2%	0.05 - 0.10
Neighborhood areas	0.50 - 0.70	Sandy soil, avg., 2-7%	0.10 - 0.15
		Sandy soil, steep, 7%	0.15 - 0.20
		Heavy soil, flat, 2%	0.13 - 0.17
		Heavy soil, avg., 2-7%	0.18 - 0.22
		Heavy soil, steep, 7%	0.25 - 0.35
Residential:		***Agricultural land:***	
		Bare packed soil	
		*Smooth	0.30 - 0.60
		*Rough	0.20 - 0.50
Single-family areas	0.30 - 0.50	*Cultivated rows*	
Multi units, detached	0.40 - 0.60	*Heavy soil, no crop	0.30 - 0.60
Munti units, attached	0.60 - 0.75	*Heavy soil, with crop	0.20 - 0.50
Suburban	0.25 - 0.40	*Sandy soil, no crop	0.20 - 0.40
		*Sandy soil, with crop	0.10 - 0.25
		Pasture	
		*Heavy soil	0.15 - 0.45
		*Sandy soil	0.05 - 0.25
		Woodlands	0.05 - 0.25
Industrial:		*Streets:*	
Light areas	0.50 - 0.80	Asphaltic	0.70 - 0.95
Heavy areas	0.60 - 0.90	Concrete	0.80 - 0.95
		Brick	0.70 - 0.85
Parks, cemeteries	0.10 - 0.25	Unimproved areas	0.10 - 0.30
Playgrounds	0.20 - 0.35	Drives and walks	0.75 - 0.85

Source：ASCE Manual of Practice No. 37

(3) Estimation of Flood Discharge by Flood Marks along the River

The results of the non- uniform flow analyses which were obtained on the basis of the profile and cross section survey of Laleia river are summarized in Table 2-10. The roughness coefficient of n=0.04 was used in the above analyses for the natural river in the mountainous area without vegetation on the bottom of the river, with steep river bank and with trees and bushes which are under water in the flood in accordance with the design criteria (Irrigation Canal by MAFF: Ministry of Agriculture, Forestry and Fisheries, Japan). The roughness coefficient of n=0.04 was also applied to the river section which consists only of boulders and stones. Although n=0.045 was obtained from the results of the flood discharge measurement. The coefficient of n=0.04 was applied to the structural design considering that n=0.04 gives a safer side design, because the larger flood discharge is obtained by n=0.04.

Table 2-10 Water Level and Flood Discharge at Laleia Head Works

	Discharge (m^3/sec)	Water Level at Head Works (WL. m)	Notes
1.	600	47.29	Water level of WL.47.5m will occur once in about 5 years
2.	800	47.62	

Source: Non uniform flow analysis based on the survey result.

The above calculation reveals that the flood discharge obtained from the elevation of the flood marks

was estimated as 600 to 800 m^3/sec. Furthermore, the interview results suggested that the frequency of the water level shown in the Table 2-11 is once in 5 years approximately. The probable flood discharge for 5-year return period was, thus, estimated as 800 m^3/sec considering the safety allowance.

The Table 2-11 indicates probable years of occurrence for annual maximum daily rainfall at the Dili Station, which also reveals that 100-years probable rainfall corresponds to 1.8 times of 5-years probable rainfall. The 100-years probable discharge is, thus, estimated as 1,440 m^3/sec (800 m^3/sec ×1.8).

Table 2-11 Probable Rainfall Intensity (Dili Station)

Probable Year of Occurrence	Rainfall Intensity (mm/day)	Ratio
2	74.6	
5	97.5	1.0
10	116.1	
25	139.6	
50	157.1	
100	174.5	1.79

The ratio of the probable rainfall intensity was employed, herein, to estimate the 100-years probable intensity from 5-year probable intensity. The flood discharge can be calculated by the rainfall intensity in the concentration time of the drainage. The 100-years probable discharge is calculated by the rainfall ratio because of the employment of the same concentration time of the drainage for 5-years probability. The above mentioned (2) and (3) are summarized in the table shown below:

Table 2-12 Calculation Results of Design Flood Discharge

	Method of Calculation	Flood Discharge (m^3/sec)
1.	Rational Formula (Daily Rainfall)	1,170
2.	Flood Mark	1,440
	Existing D/D Report (Reference)	1,033

The maximum value of the above mentioned flood discharge was employed (1,440 = 1,500 m^3/sec) for the design flood discharge.

2-2-2-3 Plan of Fixed Weir

(1) Design Flood Level

The design flood level is defined as the upstream water level at the weir crest which is required to enable to release the design flood discharge from the weir length (191.8 m) which excludes the length of the scouring sluice (Refer to (2) Fixed Weir).

Basic Design Condition

- Design flood discharge（100-yearyear probability） : Q=1,500 m^3/sec
- Fixed weir length : L1=192.9 m
- Weir crest elevation（design intake water level） : EL. 46.300 m

Overflow water depth (H) is calculated from the following equation:

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

where:

Q : Design flood discharge（1,500 m^3/sec）

C : Overflow coefficient（1.704*：Coefficient for critical water depth considering design for the safer side）

L : Fixed weir length（192.9m）

$$H = (Q/C \cdot L)^{2/3} = (1{,}500/1.704 \times 192.9)^{2/3} = 2.751 = 2.8\text{m}$$

Accordingly, the design water level (HWL) : 49.1 m

HWL=Fixed weir crest elevation 46.3m + 2.8m = HWL. 49.1 m

The crest elevation of the flood protection dike is EL.50.1 (49.1 + 1.0m as the free board required by Structural Code for River Control Facilities for a design discharge of 1,500 m^3/sec).

*: Coefficient for overflow in the critical water depth will be: C= 1.704 in accordance with the following equation: (where, hc : critical water depth)

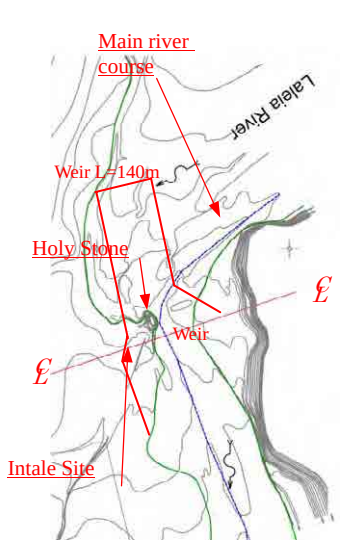
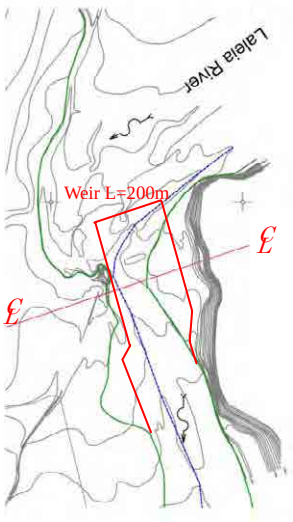
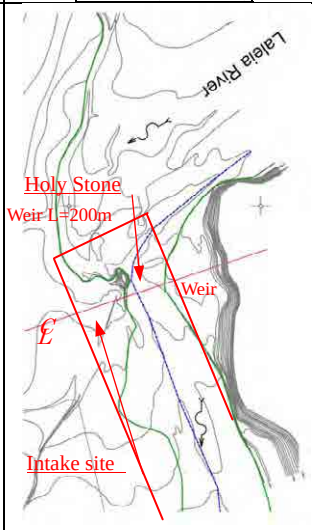
$$\left.\begin{array}{l} q = C \cdot h^{3/2} \cdots h = \dfrac{q^{2/3}}{C^{2/3}} \\ hc = \left(\dfrac{q^2}{g}\right)^{1/3} = \dfrac{q^{2/3}}{g^{1/3}} \end{array}\right\} \quad \begin{array}{l} h = 1.5 h_c \\ C^{2/3} = \dfrac{g^{1/3}}{1.5} \end{array} \qquad C = \frac{g^{1/2}}{1.5^{3/2}} = \frac{3.13}{1.5^{3/2}} = 1.704$$

(2) Fixed Weir

1) Length of Fixed Weir

Based on the results of the comparison study of the length of the fixed weir, Case-B (Weir length is 200m including 7.1 m of width of the scouring sluice) was finally selected as shown in Table 2-13, by comparing the river and topographic conditions of the proposed construction site of the headworks.

Table 2-13 Comparison of Weir Length

	Case-A (L=140m)	Case-B (L=200m)	Case-C (L=250m)
1. Preliminary Plan			
2. Relation with Gut (main river course)	In the present condition, the gut flow collides with the Holy Stone in the right bank upstream of the fixed weir, and, changes the flow direction from the downstream to the left bank and finally to the downstream. As shown in the above figure, the topographic condition is favorable because the intake structures are located at the immediate downstream of the right bank of Holy Stone where the gut flow is stable. ◎Very much advantageous	Case-B is almost same as Case-A and thus, the topographic condition between the intake structures and the gut are favorable. ◎Very much advantageous	The present gut is as shown in the above figure. This plan aims to remove the Holy Stone and widen the river course with a river width of 150m toward right bank side. The proposed intake structures are provided at the new right bank side. The gut shall be also relocated toward new right bank side. △Less advantageous
3. Design Flood EL	The draft D/D is summarized below. ・Fixed weir crest：EL.46.3m ・Design flood discharge：Q=1,500 (m^3/s) Design Flood Water Level HWL ・Discharge coefficient：C=1.704 (overflow) ・Water depth (overflow)： $H=\left(\frac{Q}{C\cdot L}\right)^{2/3}$ =3.527m ・Design flood WL：HWL =EL.46.3+H≒49.8m (※) The overflow length L': L=140m minus 7.1m for scouring sluice width=132.9m. Compared to Case-B and・C, the design flood WL is the highest, and therefore, there is a concern on the influence to the upstream farm land. The scale of the downstream facilities (apron/ river bed protection works) are the largest among the 3 plans. △Less advantageous	Same as Case-A ・Fixed weir crest：EL.46.3m ・Design flood discharge：Q=1,500 (m^3/s) Design Flood Water Level HWL ・Discharge coefficient：C=1.704 ・Water depth (overflow)： $H=\left(\frac{Q}{C\cdot L}\right)^{2/3}$ =2.751m ・Design flood WL：HWL =EL. 46.3+H=49.1m (※) The overflow length L': L=200m minus 7.1m for scouring sluice width=192.9m. Case-B is the intermediate plan between Cases-A & C. ○ Advantageous	Same as Case-A ・Fixed weir crest：EL.46.3m ・Design flood discharge：Q=1,500 (m^3/s) Design Flood Water Level H.W.L ・Discharge coefficient：C=1.704 ・Water depth (overflow)： $H=\left(\frac{Q}{C\cdot L}\right)^{2/3}$ =2.359m ・Design flood WL：HWL =EL. 46.3+H=48.7m (※) The overflow length L': L=250m minus 7.1m for scouring sluice width=242.9m. Compared to Case-A and B, this plan is the most advantageous for the farm land in the upstream and the facilities in the downstream because of the lowest design flood water level. ◎Very much advantageous

	Case-A (L=140m)	Case-B (L=200m)	Case-C (L=250m)
4. River Configuration	・ In the right bank, the Holy Stone will remain at the same position and the present downstream bank is strengthened by the new protection dike with an approximate length of 400m connected rectangular to the dam axis. ・ In the left bank, there is natural ground with a width of 120 m from the left bank consisting of sediment sand. One half of the 120 m is included in the weir with a width of 140 m in total for the length of the proposed weir. The remaining distance of 60m between the left bank end of the proposed weir and the natural ground is planned to be protected by flood dike. ・ The proposed weir width is narrower than the present width of the river bed, which is less flow capacity compared with the present capacity.	・ Facilities for the right bank are the same as those for Case-A. ・ In the left bank, the entire sediment sand area with a width of 120m will be total used for the foundation of the proposed weir. The flood protection dike with a length of about 120 m is proposed to construct which intersects with weir axis at right angle and connects with the natural bank smoothly. ・ Compared with narrow river section in Case-A, Case=B maintain almost same width of the flow section by widening. Therefore, no adverse impact is anticipated to the downstream in flood.	・ In the right bank, the flood protection dike is proposed along the present natural bank at the upstream portion, and proposed to extend keeping a distance of 140m from the present river bed as shown in the plan. ・ In the left bank, the sediment sand shall remain as it is. The bank protection work shall be provided along the boundary of the natural ground and sediment. The flood protection embankment shall be provided. ・ Large impact to the down- stream is anticipated by the relocation of the main river course toward the right bank.
5. River Regime during Flood Discharge	・ There will be concerns or problems of flushing and scouring of the sediment deposit under the proposed weir and embankment. Attention shall be paid to the security of the downstream apron and riverbed protection. △Less advantageous	・ In comparison with Case-A, there is no adverse impact anticipated to the flow regime in flood due to countermeasures by widening in the left bank and bank protection work. ○ Advantageous	・ In comparison with Cases A & B, there is no adverse impact anticipated to the flow regime in flood due to countermeasures by the longest weir crest and straight configuration of downstream bank. ◎Very much advantageous
6. Relation with the Holy Stone	・ There is a small pillow basaltic mountain at the right bank natural ground which is called as Holy Stone by the local people which may be difficult to remove and better to leave as it is. ○	・ Same as Case-A ○	・ Removal of the Holy Stone is planned. However, it is judged to be impossible considering the condition of local society. △Less advantageous
7. Excavation Volume	・ Weir body portion: Excavation volume is the least among 3 plans because of the less excavation volume due to the shortest weir length. ・ River bed portion: It is necessary to remove sediment deposit at the left bank river bed though it is smaller volume compared to Case-B. ・ As a whole, it is not necessary to remove the Holy Stone and there is less excavation volume compared to the other 2 plans. ◎	・ Weir body portion: The weir length is inter-mediate between Case-A & C, thus the excavation volume as well. ・ River bed portion: Excavation is required for removal of the sediment deposit at the left bank ・ Intermediate volume of excavation between Case-A & C is required for removal of sediment deposit. ○	・ Weir body portion: Weir is the longest compared to the other two cases and thus it needs the largest excavation volume among the 3 cases. ・ River bed portion: Large excavation volume is required for removal of Holy Stone and natural ground at the right bank though no removal of sediment deposit is needed. ・ The largest volume of excavation is required among the 3 cases which include removal of Holy Stone. △

	Case-A (L=140m)	Case-B (L=200m)	Case-C (L=250m)
8. Land Acquisition	・ The area to be acquired is relatively small because most of the weir facilities are constructed in the area of the river bed and only limited land will be acquired in the right bank natural ground owned by the local people for the related facilities. ○	・ Same as Case-A ○	・ Land acquisition of the right bank private land is appreciable which include Holy Stone. △
9. Construction Cost	Less	Medium	Large
10. Overall Evaluation	・ The most economical among 3 plans and not necessary to remove the Holy Stone, but there is a concern of back water effect on the upstream farm land due to the highest design flood water level. ・ Safety of the proposed facilities such as the downstream apron and river bed protection work is a matter of concern due to flowing boulders by the highest flood level among the 3 plans. ○ Advantageous	・ Economically medium among 3 plans, and removal of Holy Stone is not required as Case-A. ・ HWL is also medium advantageous among 3 plans, thus, adverse impact is less anticipated to the upstream farm land and risks against downstream apron and river bed protection ◎Very much advantageous	・ Economically most dis-advantageous. It is extreamly difficult to obtain agreement of local society for removal of Holy Stone. ・ River configulation and land acquisition are dis-advantageous compared with other two plans. ◦ △Less advantageous

2) Foundation of Fixed Weir

The ground elevation of the foundation surface of the fixed weir, Irrigation canals and sediment trap were designed considering the results of the test pit and trench carried out under this study. The Geological map is shown in Figure 2-5. The ground elevation of the fixed weir, scouring sluice and intake structures were decided as EL. 40.5m at the right bank and EL.42.0m at the left bank of the gravel layer mixed with boulders. According to the D/D report, the gravel layer mixed with boulders was defined that the number of blows in Standard Penetration Test (SPT) was 50 times at a depth of 2.45m from the ground surface (EL. 41.5m). The number of blows in the SPT was also confirmed at the site by the Design Criteria of Japanese Association of Soil Mechanics through the test trench of the compacted sand and gravel layer mixed with boulders at EL.40m by a backhoe (equivalent bearing capacity).

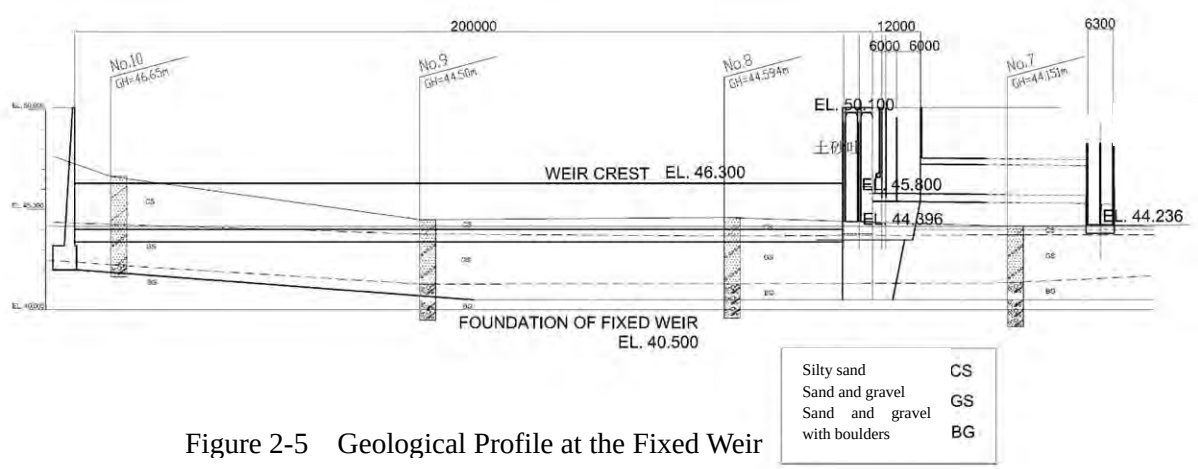


Figure 2-5 Geological Profile at the Fixed Weir

3) Standard Section of the Fixed Weir

The standard section of the fixed weir was calculated as mentioned below in accordance with the standard design:

- The trapezoidal section with a vertical upstream slope and the downstream slope (1:1.0) as employed generally[1] are followed; a quarter circle at the upstream end of the crest and appropriate curve at the downstream end of the crest are considered.
- The elevation of the weir crest is EL. 46.30m which is shown as the design intake water level in Sub-section (3) mentioned below.
- The upstream apron is designed for the purpose of protection of the upstream riverbed from scouring. The length of the upstream apron (l_3) = 6.0m to protect the weir body and foundation of cut off wall from scouring, and thickness of the upstream apron t_3=0.6m which is normally 1/2 to 2/3 of the thickness of the downstream apron, i.e., (thickness of the upstream apron (0.6m) = (thickness of the downstream (1.0m) x (1/2 to 2/3) = 0.5-0.67).
- The downstream apron is designed for the purpose of the protection of the river bed of the downstream of the proposed weir from scouring.
  The length of the downstream apron is calculated as follows:

$$l_1 = 0.6 \cdot C\sqrt{D_1}$$

where: l_1 : Length of the downstream apron (m)

D_1 : Height from the upper surface of the downstream end of the apron to the weir crest (m)

=EL. 46.3 - EL. 44.0 = 2.3m

C : Coefficient in Bligh's formula (C=4 for sand and stones)

$$l_1 = 0.6 \times 4 \times \sqrt{2.3} = 3.64 = 4.0\text{m}$$

The length of the downstream apron should be corresponding to the apron length of the scouring sluice (6.0m). However, since the most of river bed protection blocks are scoured in Timor-Leste, the longer downstream apron is considered to be applied instead of the river bed protection blocks, i.e., the river bed protection blocks will not be applied. Consequently, l1=15.0m was applied in this case considering the construction length of the river bed protection blocks.

4) Seepage Creep Length

In order to protect the structure foundation from piping, it is necessary to provide sufficient creep length against seepage along the weir foundation, and behind the bank protection retaining wall. The design creep length is decided by the larger length obtained from 1) Bligh method to protect t 2) Lane method to protect the structure Design Criteria for Headwork.

The maximum difference of water levels between the upstream and downstream side can be obtained from the weir crest (2.3 m) and the river bed elevation as the lowest water depth (0 m) considering some safety allowance. In order to counter uplift, weep holes are designed for the cut off at the end of the downstream apron. Therefore, the creep length does not include the length of

the cut off.

・Creep length by Bligh depth (0m)

$$S \geq C \cdot \Delta H = 4 \times 2.3 = 9.20\text{m} \leq 25.4\text{m}$$

where:

S : Creep length measured along the surface of the weir foundation as shown in the figure below (m)

S=4.00 + 2.4 +1.00 + 18.0 = 25.4 m

C : Coefficient of Bligh's formula (C=4 for sand and gravel)

ΔH : Maximum water drop between the up- and down-streams (⊿H=2.30m)

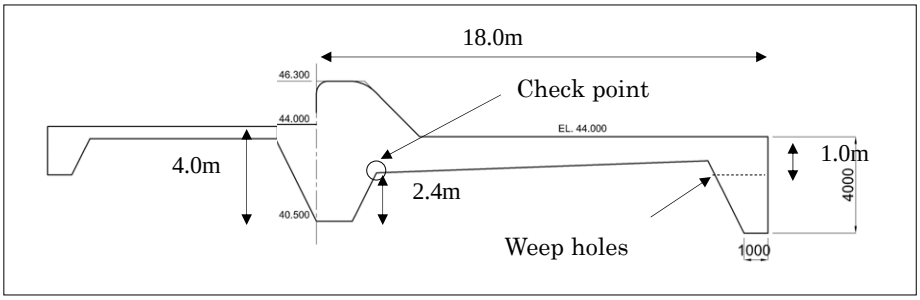


Figure 2-6 Typical Cross Section of Fixed Weir

・Creep length by Lane's formula

$$S \geq C' \cdot \Delta H = 2.5 \times 2.3 = 5.75\text{m} \leq 14.4\text{m}$$

where:

L : Weighted creep length (m)

l_v is the vertical length and l_h is the horizontal length in the above formula

L= (4.00 + 2.40+ 1.00) +1/3×18.00= 14.4 m

C' : Weighted coefficient of Lane's formula (C'=2.5 for boulders, including cobble stones and gravels)

ΔH : Maximum drop between up- and down-streams (⊿H=2.30m)

Accordingly, the length of 15 m of the downstream apron satisfies the creep lengths of both the formula.

5) Thickness of the Downstream Apron

$$t \geq 4/3 \cdot (\Delta H - H_f) / (\gamma - 1)$$

where: t : Thickness of apron at the check point (m)

ΔH : Maximum water drop between up- and down-stream (ΔH=2.30m)

H_f : Head loss of seepage water up to the check point (m)

γ : Specific gravity of the material of the weir and apron (γ=2.35 t_f/m^3)

4/3 : Factor of safety

$$t \geq 4/3 \times (2.3 - 0.72)/(2.35 - 1) = 1.56\text{m}$$

The thickness of the downstream apron was decided as 1.6m after checking with the apron thickness of the scouring sluice.

(3) Scouring Sluice

1) Upper Portion of Scouring Sluice

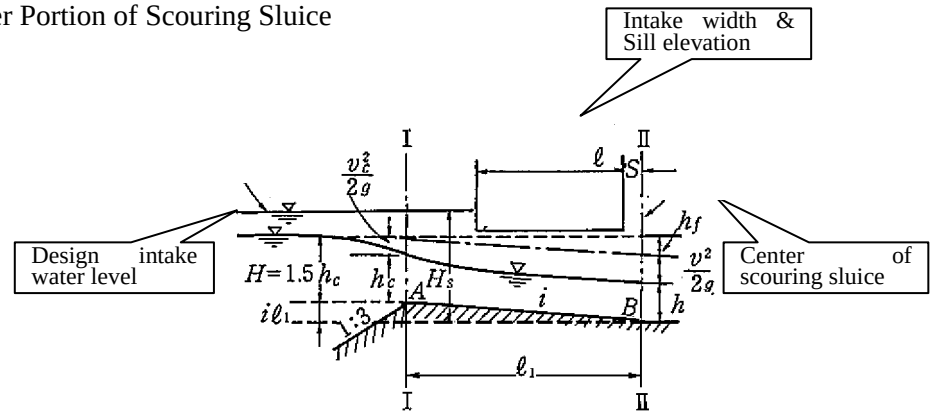


Figure 2-7 Upper Portion of Scouring Sluiceway

$l_1 = S + l + 1.5 \times Hs$

where: l_1 : Length of upstream canal of scouring sluice (m)

l : Width of upstream of intake (m) =8.4 m

S : Distance between upstream end of scouring sluice gate and downstream end of intake =2.5 m

Hs : Difference between sill elevation of scouring sluice and design intake water level (m)

=NWL. 46.3m - EL. 44.30m=2.00 m

$l_1 = 2.5 + 8.4 + 1.5 \times 2.0 = 13.90 = 14.0$ m

The gradient of upstream canal of scouring sluice is about 1/100 considering required tractive force. Accordingly the sill elevation of scouring sluice canal is EL.44.3m in accordance with the following equation:

Elevation of scouring sluice canal = Present river bed elevation of upstream end of scouring sluice canal – i × l1

=EL. 44.5－1/100 4.5 of scouring sl m=44.3 m

2) Canal Width of Scouring Sluice

The width of the scouring sluice canal is designed so as to make the velocity in the scouring sluice canal about 0.4 m/sec by the normal intake in the rainy season. Two sets of scouring sluice gate with a width of 2.5m (5.0m/2 sets) and a height of 2.1 m (=NWL.46.3 – EL.44.3 m) were designed.

3) Longitudinal Gradient of Scouring Sluice

The scouring sluice canal has supercritical flow under the normal flow condition. The longitudinal gradient of the canal is designed so as to flush the objective maximum grain size (dmax=40 mm) by the fully opened scouring sluice gate. The condition of the supercritical flow is as follows:

- Velocity : $Ve=\sqrt{20}dmax=\sqrt{20}\times 0.04=0.89$ m/sec
- Depth : $hc=Vc^2/g=0.89^2/9.8=0.08$ m
- Slope : $ic=(n^2\times g) / hc^{1/3}=(0.020^2\times 9.8) / 0.08^{1/3}=0.0091=1/109$

The following longitudinal gradient will be designed for the scouring sluice canal which is steeper than the supercritical slope, considering the longitudinal gradient of scouring sluice canal, upstream and downstream of scouring sluice canal and the length of the gate portion of the scouring sluice:

- Upstream of scouring sluice gate : 1:60.5
- Downstream of scouring sluice gate : 1:52.1667

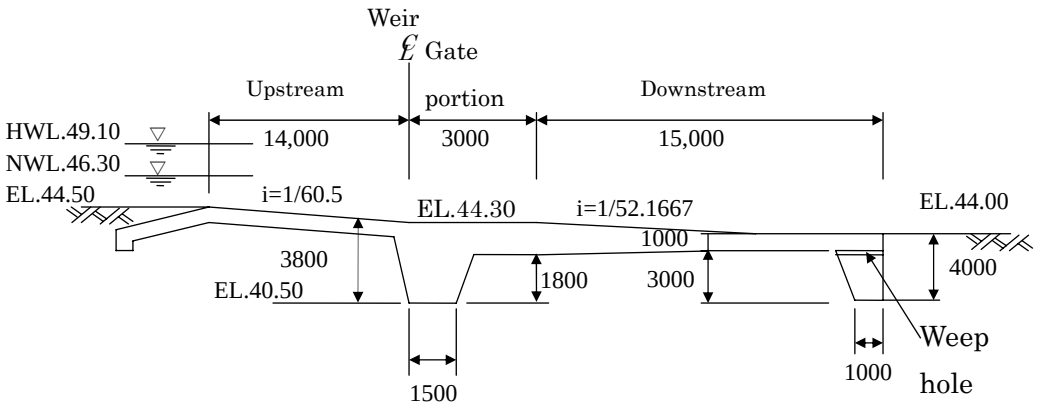


Figure 2-8 Profile of Sediment Flush Canal

4) Others

One set of steel screens is designed at the upstream end of the scouring sluice in order to maintain the function of the intake facilities and to avoid the entrance of stones of larger size, etc. The height of the screen is planned as 4.6 m from the sill elevation of upstream end of scouring sluice (EL. 44.5 m) to the design flood elevation (HWL. 49.1 m).

(4) Intake Facilities

1) Intake Structure

i) Sill Elevation of Intake Structure

It is necessary for the intake sill elevation to be 1.0 m higher than the sill elevation (EL. 44.50m) of the scouring sluice in order to minimize the entrance of soil and sand into the irrigation canal system (refer to Design Criteria for Head Works). The sill elevation of the entrance of the intake is designed as EL.45.80 m which is 1.3m higher than the sill elevation of the upstream end of the scouring sluice considering the entire profile of the irrigation system including the intake structure, sediment trap, intake canal, connecting canal and all irrigation canals.

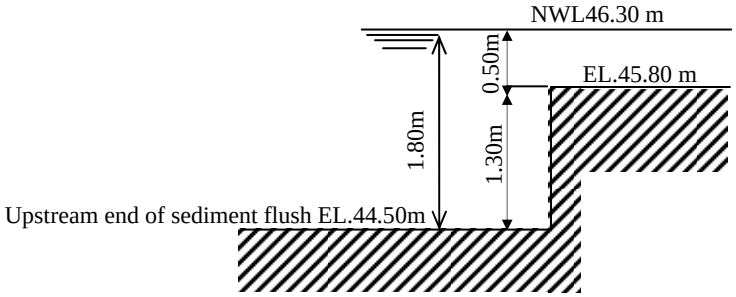


Figure 2-9 Sill Elevation of the Intake

ii) Width of Intake Structure

In general, the flow velocity at the entrance of the intake structure is 0.6 to 1.0 m/sec in order not to permit entrance of stones and growing of aquatic plants in the main canal. An average of V=0.8 m/sec is, thus, applied to the intake.

The total required width of the intake is assumed as 6.0 m, which means 1.5 m wide and 4 spans.

$$B = \frac{Q}{(h_1 \cdot V)}$$

where: B : Total width of the intake structure (m)

Q : Design intake discharge（2.290 m^3/sec）
Although the intake discharge was estimated as 1.908 m^3/sec, 20% was considered as allowance (1.908×1.2=2.290m^3/sec) in accordance with p.80, Irrigation Design Standards, Design Criteria Volume Headworks: KP-2, Indonesia）

h_1 : Intake water depth（0.5m）

V : Intake flow velocity (0.8 m/sec）

In accordance with the above equation, B=5.725=6.0m is applied as shown below.

$$B = \frac{2.290}{(0.5 \times 0.8)} = 5.725\text{m}$$

iii) Design Intake Water Level

Design Intake Water Level: NWL（Crest elevation of the fixed weir）is EL. 46.30m calculated as shown below:

Design Intake Water Level: NWL = Sill elevation + Inflow depth = EL.45.80+0.5m = EL. 46.30m

(5) Sediment Trap

The following conditions are applied for planning of the sediment trap:

1) Capacity of the Sediment Trap

The sediment trap shall be designed so as not to allow the irrigation water to include soil particles with a diameter larger than 0.07 mm. Muddy river water sampling was made at the time of the rain storm with thunder. The result of the sampling and gravity test revealed that the dry density of the soil and sand content was 0.39%, which meant 0.004 ton/1m^3/sec of water intake. The capacity of the sediment trap was estimated at 440 m^3 under following conditions:

- Intake discharge : 1.908 m^3/sec（Maximum intake）
- Sediment particle content : 10% of soil particles included in the river water is grain size of 0.07mm or more
- Unit weight of soil & sand : Unit weight in water of sediment trap is assumed as 1.0 ton/m^3
- Frequency of sediment removal : Once in 6～7days

The required capacity of the proposed sand trap is:

V=1.908×86,400sec×0.0039×0.1×6～7days=386～450 m^3.

Width of sand trap: 8m, length: 50m, effective water depth: 1.1m (0.8m at the upstream end and 1.35m at the downstream end of sand trap basin) were necessary.

Accordingly,

Vbasin = 8m×50m×1.1m=440 m^3 was designed.

2) Configuration of Sand Trap Basin

The canal section of the sediment trap basin is rectangular. The basin is divided by a partition wall in 2 canals so that it is possible to supply water by one canal and to flush sediment by the other canal.

The length of the sediment trap shall be sufficient for the inflow of soil particles with a size of 0.07mm or more to fall and to reach at the canal bed of the basin before the downstream end of the basin. The results of the hydraulic calculation revealed that the velocity in the basin was 0.12 m/sec and the falling velocity of the soil with a diameter of 0.07mm was 0.004m/sec (refer to Figure

2-10). The required length of the basin was estimated as 50 m as calculated below:

Falling time = 1.7m / 0.004 m/sec = 425 sec

Required length of the basin = 0.12m/sec × 425 sec=51.0 m

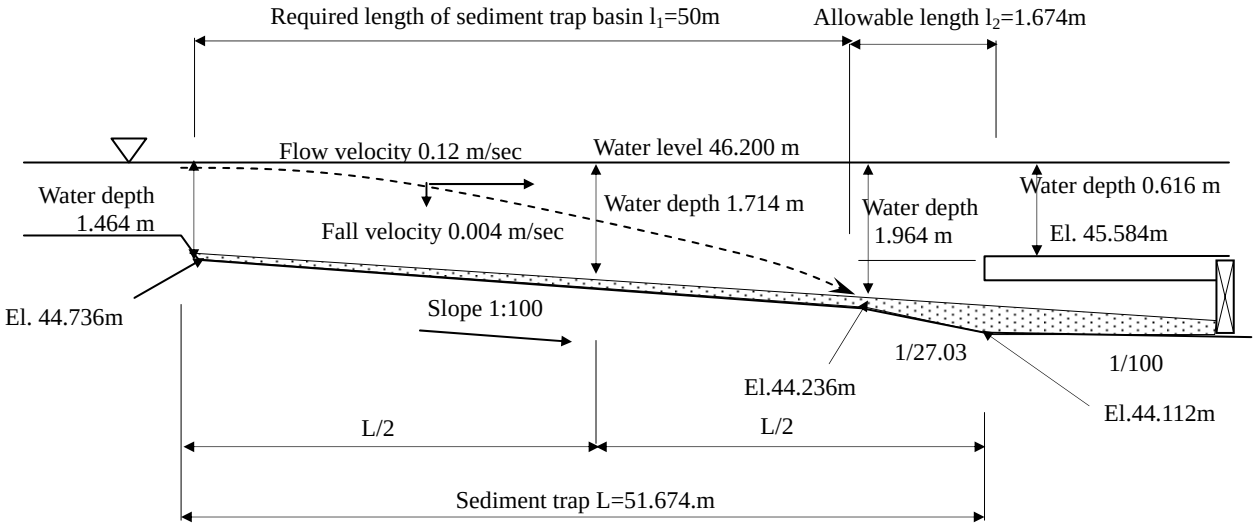
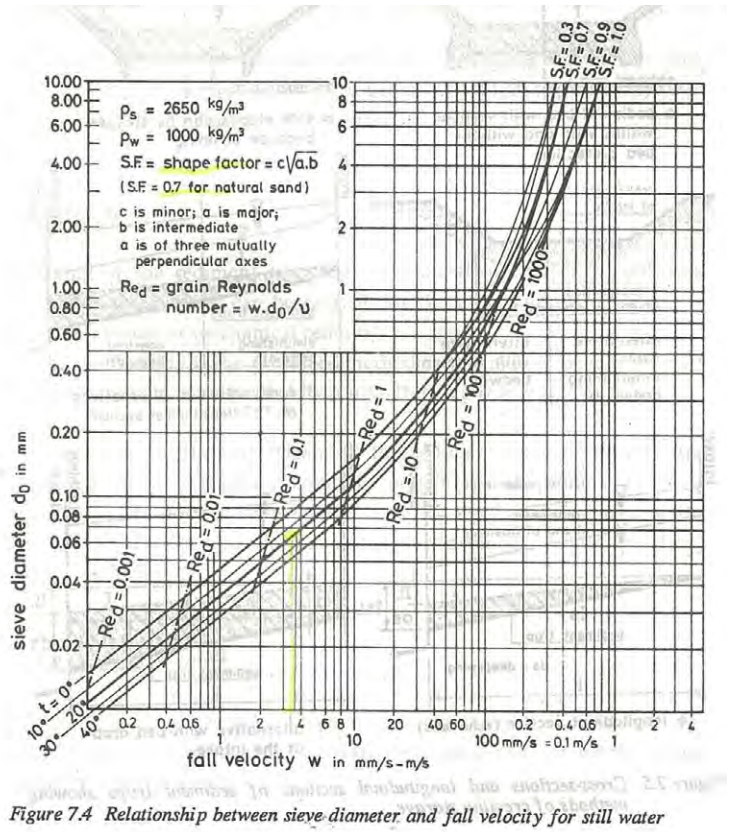


Figure 2-10 Hydraulics in Sediment Trap Basin



Source : p.139, Irrigation Design Standards, Design Criteria Volume Headworks : KP-2, Indonesia）

Figure 7.4 Relationship between sieve diameter and fall velocity for still water

Figure 2-11 Relationship between Sieve Diameter and Fall Velocity

(6) Spillway for Sediment Trap Basin

The intake water volume is controlled by the adjustment of gate opening based on the irrigation water required by the benefitted area. However, it is presumed that the flood might occur in the downstream irrigation canal by overflow of the excessive water inflow from the intake due to sudden raise of river water level. It is, therefore, necessary to discharge such excessive water by spillway to be planned at the sediment trap. The excessive inflow discharge can be calculated by the following equation under the conditions of the increased river water level of 0.5m and of full opening of all of the intake gates

$$Q = CA\sqrt{2 \times g \times h}$$

where: Q : Excessive discharge（m^3/sec）
C : Discharge coefficient（0.65）
A : Gate opening area（4gatesopening areaentd^2）
h : Height of the river water raise（assumed at 0.5m）

The increased excess water is, thus, calculated at 9.767 m^3/sec as follows:

$$Q = 0.65 \times 4.8 \times \sqrt{2 \times 9.8 \times 0.5} = 9.767 m^3 / \sec$$

Herein, the overflow discharge coefficient for the spillway was assumed as 2.0, and the overflow depth was assumed as 0.5m. The spillway canal was planned with a width of 15m = 7.5m x 2 spans. The length of the spillway is 14.4 m (15 m - 0.3 for side wall x 2).

$$L = \frac{Q}{C \times H^{3/2}} = \frac{9.767}{2.0 \times 0.5^{3/2}} = 13.8m \rightarrow 14.4m$$

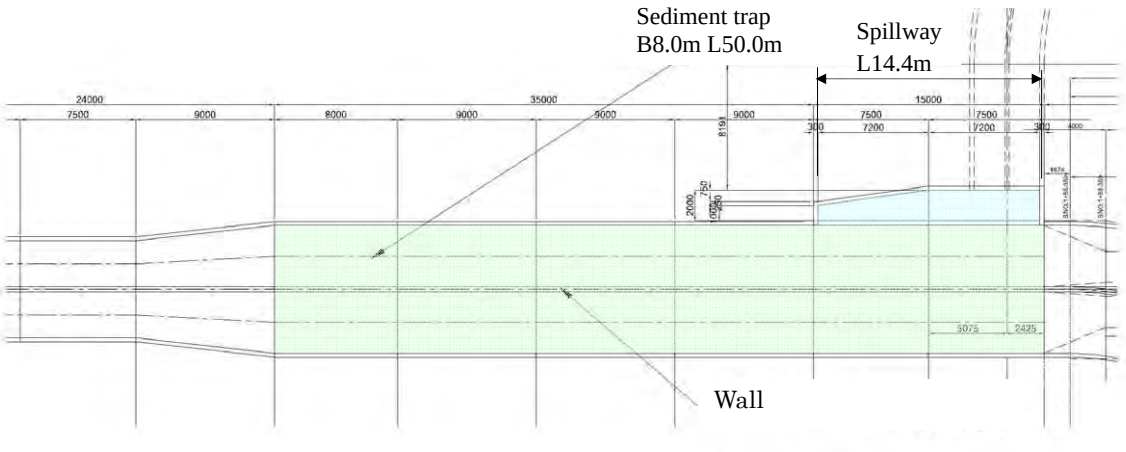


Figure 2-12 Plan of Spillway Canal

The hydraulic calculation results for the section of the side spillway are shown in Table 2-15. The water level of the side spillway canal is higher at 9.0m downstream from the upstream end than the crest elevation (EL. 46.300m), and it was confirmed that the overflow coefficient was not affected by the following study for the case where it is affected by the water level in the side spillway at the downstream of the weir.

(After Design Criteria for Dam)

In cases where the apron of the weir downstream is as low as more than 3.5 times of the overflow depth （(hd+d)/H>3.5, the overflow discharge coefficient is not affected by the height of the downstream apron (i.e., backwater effect), but affected only by the water level in the side spillway. With respect to the range of this influence, the relationship between the weir downstream W.L. and the total hydraulic head is represented by hd/H, and the variation of this factor and the discharge coefficient can be illustrated as indicated in Figure 2-13. In accordance to the following equation, hd/H=0.73 was obtained, which revealed almost no influence to the overflow discharge coefficient.

$$\frac{h_d + d}{H} = \frac{0.365 + 2.175}{0.5} = 5.08 \geq 3.5$$

$$\frac{h_d}{H} = \frac{0.365}{0.5} = 0.73$$

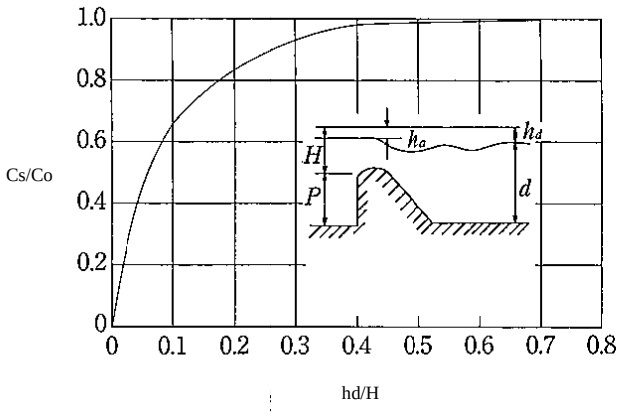


Figure 2-13 Variation of Weir Downstream W.L. and Discharge Coefficient

The structure of the downstream canal of the spillway is the box culvert of 2 span x 2.0m and a height of 1.5m.

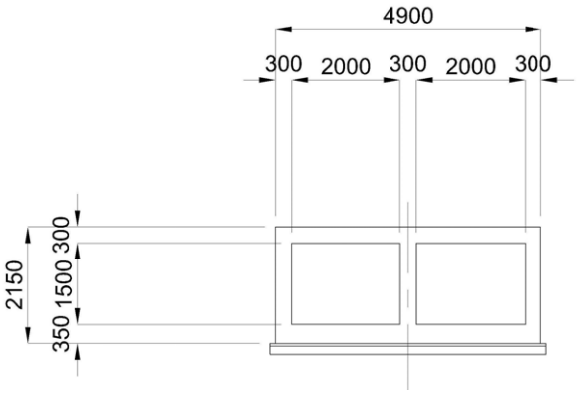


Figure 2-14 Spillway Downstream Box Culvert

The profile of the outlet discharge box culvert is shown in Figure 2-14

- Width of Box Culvert: 4.0 m

- Supercritical Depth: 0.847 m (Figure 2-14 Point A of Slope Change)
- Downstream Water Level d1: 0.475m (Figure 2-14 Point B of Slope Change)
- Depth of Hydraulic Jamp d2：

$$h_c = \left(\frac{Q^2}{g \cdot b^2} \right)^{1/3} = \left(\frac{9.767^2}{9.8 \times 4.0^2} \right)^{1/3} = 0.847\text{m}$$

where: h_c : Critical Depth（m）
Q : Discharge（m^3/sec）
b : Canal Width（m）

The downstream water level is equal to 1.379m according to the equation mentioned below.

$$\frac{d_2}{d_1} = \frac{1}{2}\left(\sqrt{1 + 8 \times F_r^{\,2}} - 1 \right)$$

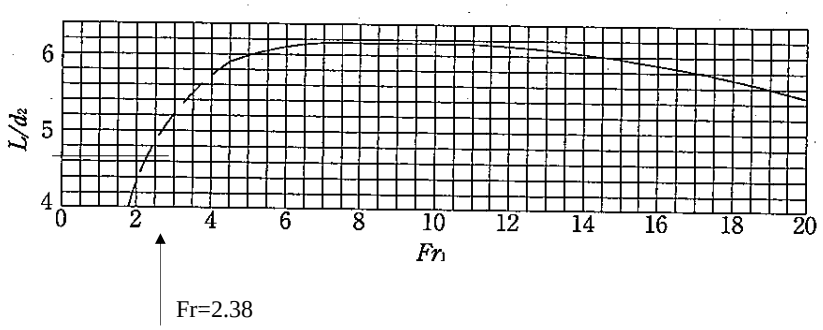
$$F_r = \frac{V}{\sqrt{g \times d_1}}$$

where : d_1 : Water depth before（m）
d_2 : Water depth（m）
Fr : Froude Number

$$F_r = \frac{V}{\sqrt{g \times d_1}} = \frac{5.141}{\sqrt{9.8 \times 0.475}} = 2.38$$

$$d_2 = \frac{d_1}{2}\left(\sqrt{1 + 8 \times F_r^{\,2}} - 1 \right) = \frac{0.475}{2}\left(\sqrt{1 + 8 \times 2.38^2} - 1 \right) = 1.379\text{m}$$

Where, assuming that the length of the natural hydraulic jump is 5, a box culvert with the horizontal floor and a length of 7.5m（1.379m assuming that）is planned at the immediate upstream of the outlet to the river in order to protect the structures from the riverbed scouring.



Source：Design Criteria
Design standard : Dum

Figure 2-15　Length of Natural Hydraulic Jump

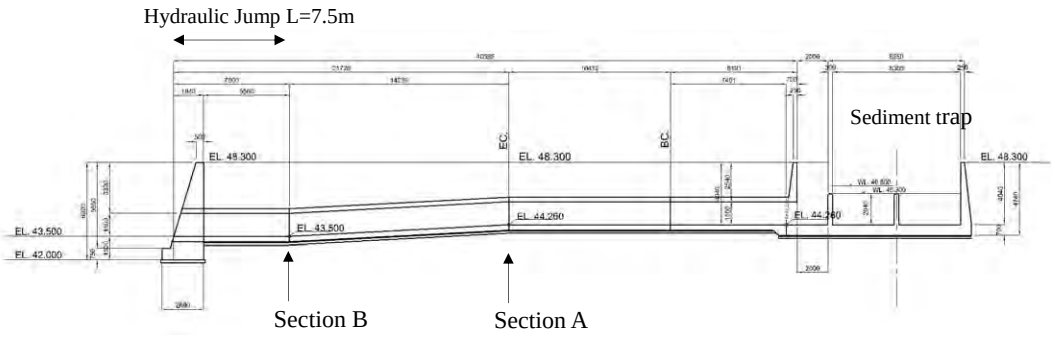


Figure 2-16　Profile of Spillway Downstream Culvert

(7) Sediment Flushing Canal

A sediment flushing culvert is planned at the end of the sediment trap.　The section of the sediment flushing consists of the culvert with a width of 2.0m and a height of 1.2m of the sediment flushing culvert considering the operation and maintenance.　The gradient of the sediment flushing culvert is designed as 1/100 to expedite the sedimentation of the canal.　The sedimentation is flushed by opening the sediment flushing gate.　The Plan and profile of the sediment flushing culvert and the cross section are shown in Figure 2-17 and 2-18, respectively.　The sediment flushing gates shall be designed so as not to prevent the irrigation by the flushing operation. Namely, one canal, which is divided into 2 canals by a partition wall, will be used for supply of the irrigation water and the other canal is simultaneously able to use for the sediment flush by operation of the sediment flushing gate.

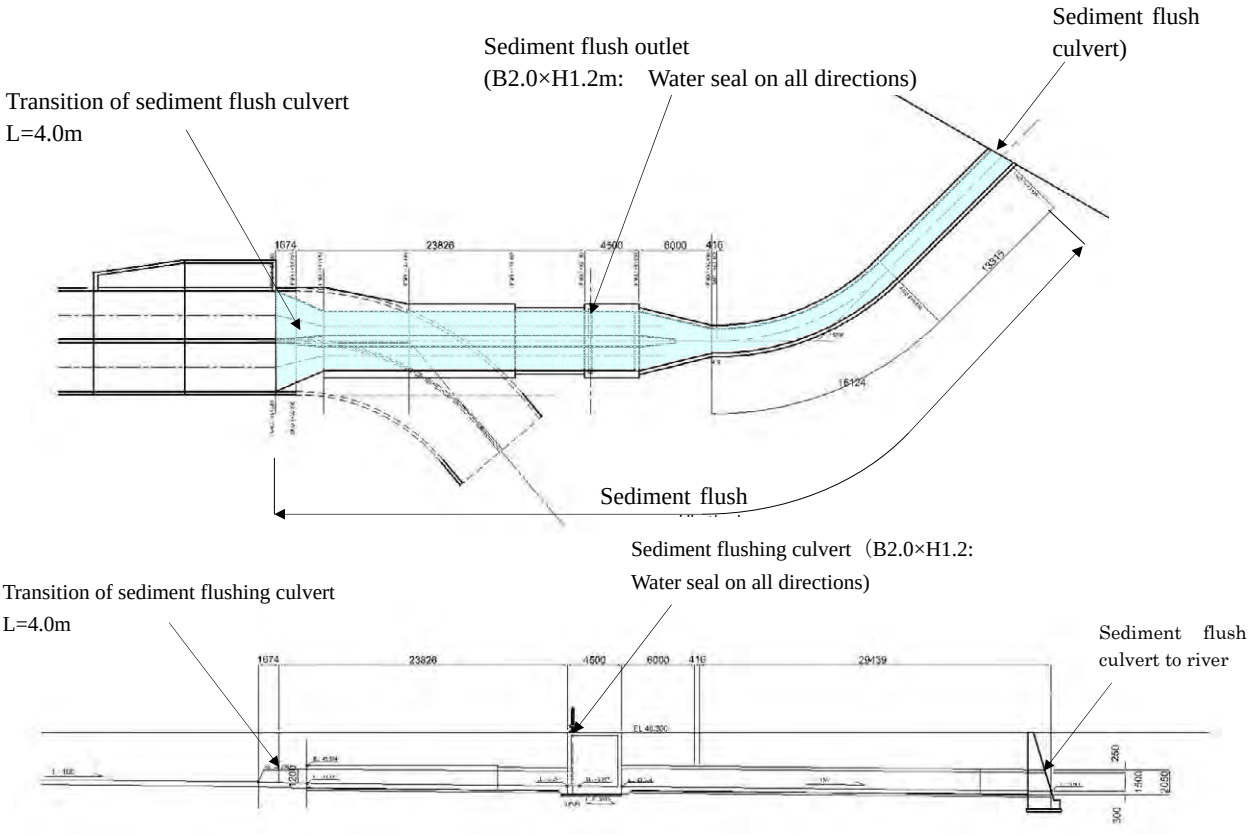


Figure 2-17　Plan and Profile of Sediment Flushing Culvert

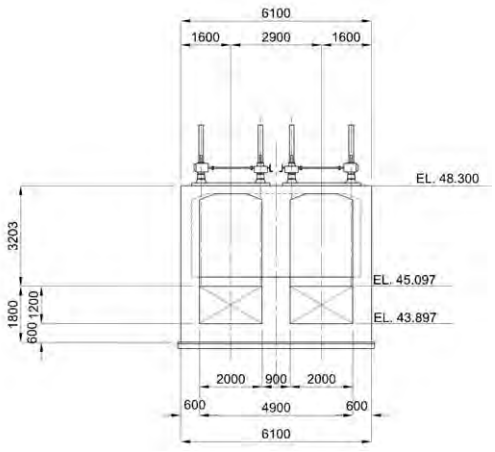


Figure 2-18　Cross Section of Sand Flush Outlet

(8) Gates for Intake Facilities

The gates of the intake structure include scouring sluice gates, intake gates, sediment flushing gates and main canal sluice gates. Screens are installed at the upstream of the sediment sluice and the upstream side of the intake gate. The screen at the scouring sluice aims to protect the gate from the entrance of relatively large size floating debris such as timbers. The screen at the intake aims to protect floating debris and falling leaves from entering to the sediment trap and the irrigation canal. Table 2-14 shows details of the gates and screens.

Table 2-14　Gate Details

	Scouring sluice gate	Intake gate	Sediment flush gate	Main canal gate
1. Gates				
Number of gate	2	4	2	2
Span × height	2.5m×2.1m (EL.44.300 - EL.46.300 + 0.10m)	1.5m×0.8m (EL.45.800 +EL.46.600)	2.0m×1.20m	2.0m×0.75m
Gate type	Roller gate (plate girder)	Roller gate (plate girder)	Roller gate (plate girder)	Slide gate (plate girder)
Water seal	3 direction	Entire 4 direction	Entire 4 direction	3 direction
Sill elevation	EL.44.300m	EL.45.800m	EL.43.897m	EL.45.550m
HWL.49.10m Design water level	HWL. 49.10m Design food water level	HWL. 49.10m Design food water level WL. 46.30m （Design intake WL $Q_{100\%}$）	WL. 49.1m Design food water level WL. 46.40m （Design intake WL $Q_{120\%}$）	WL.46.300m（H=0.75m）
2. Hoist				
Type	Rack type（Manual）	Rack type（Manual）	Rack type（Manual）	Rack type（Manual）
Hoisting speed				
Hoisting load				
3. Stop log				
Type	Wooden	Wooden	Wooden	Wooden
Span × height	2.5m×0.3m×10sets （h=3.0m） （EL.44.3+3.0m=EL.47.3m）	1.5m×0.5m×3sets×4 門 （h=3.0m） （EL.45.8+1.5m=EL.47.3m）	None	2.0m×0.5m×2sets×2s （h=3.0m） （EL.45.55+1.0m=EL.46.55m）

	Scouring sluice gate	Intake gate	Sediment flush gate	Main canal gate
Water seal	Rubber seals at 4 edges	Rubber seals at 4 edges	－－－	Rubber seals at 4 edges
Hoist	Hook	Hook	－－－	－－－
4. Screen				
Type	Steel panel*[1]	Steel panel*[1]	Not installed	Not installed
Span × height	L6.2m×H5.1m×1sets （EL.44.50m-EL.50.1m-0.5m）	1.5m×0.835×4sets 0.835m=1:0.3×0.8m (EL.44.50m-EL.45.30m) （Bar interval: 75mm）	－－－	－－－
Stop log*[2] Span	L6.2m×0.3m×8sets （h=3.0m） （EL.44.5+2.40m=EL.46.9m：0.6m higher than weir crest (EL.46.9m) （Bar interval: 200mm）	－－－	－－－	－－－

*[1]：In flood season, the debris is represented by floating timber with a diameter of 50cm, length of 6m and velocity of 4m/sec.

*[2]：Installation of structure steel of L-50mm x 50mm on both top and bottom surface of a Timber with a size of W50mm×H300mm

(9) Intake Headrace Channel

The results of the hydraulic calculation are shown in Table 2-15. The hydraulic loss of screen was calculated as 0.047m in accordance with the equation shown below:

$$\Delta h_r = h_r + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right) = f_r \frac{V_1^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right)$$

$$f_r = 6.69 \cdot \sin\theta \cdot \left(\frac{t}{b} \right)^{4/3} \exp\left(0.074 \cdot \gamma_w \cdot \frac{a}{H} \right)$$

where:

$\triangle h_r$	:	Head loss due to screen（m）
h_r	:	Hydraulic loss by screen（m）
V_1	:	Average flow velocity at the upstream side（m/sec）
V_2	:	Average flow velocity at the downstream side（m/sec）
g	:	Gravitational acceleration（m/sec^2）
f_r	:	Coefficient of hydraulic loss by screen
a	:	Depth of debris attached to screen（m）
H	:	Water depth of the upstream of the screen（m）
γ_w	:	Unit weight of wet floating debris（kgf/m^3）
θ	:	Inclination of Screen（°）
t	:	Thickness of screen bar（m）
b	:	Clearance between screen mesh (m)

$$f_r = 6.69 \times \sin 73.3 \times \left(\frac{0.009}{0.075} \right)^{4/3} \times \exp(0.074 \times 200 \times 0.1) = 1.666$$

In cases where, Q100%=1.908 m^3/sec, $\triangle$hr is estimated as 0.05m, and the water level of the upstream

of the screen is El. 45.800m + 0.380m of water depth of the downstream + 0.05m of screen head loss = WL. 46.23m, which is lower than the weir crest elevation (El. 46.30m).

$$\Delta h_r = f_r \frac{V_1^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right) = 1.666 \times \frac{0.837^2}{2 \times 19.6} + \left(\frac{0.740^2}{2 \times 19.6} - \frac{0.837^2}{2 \times 19.6} \right) = 0.05\text{m}$$

Similarly, in cases where, Q120%=2.290 m^3/sec , △hr is estimated as 0.05m, and the water level of the upstream of the screen is El. 45.800m + 0.45m of water depth of the downstream + 0.05m of screen head loss = WL. 46.30m, which is same as the weir crest elevation (El. 46.30m).

$$\Delta h_r = f_r \frac{V_1^2}{2g} + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g} \right) = 1.666 \times \frac{0.843^2}{2 \times 19.6} + \left(\frac{0.751^2}{2 \times 19.6} - \frac{0.843^2}{2 \times 19.6} \right) = 0.05\text{m}$$

The hydraulic details of the sections of the headrace of the intake structures are shown in Table 2-15. This table indicates both results of the water level calculation for the design intake discharge (1.908 m^3/sec) as well as for the design intake discharge + additional 20% of allowance (2.290 m^3/sec in total) as described in sub-section (3)“Intake Structure”.

Table 2-15 Water Levels of Intake Headrace for the Design Discharge with 20% of Allowance

Station No.	Distance	Accumulated Distance	Canal Bed Elevation	Canal Width	Water Depth	Water Level	Water Depth	Water Level
					$Q_{100\%}=1.908m^3/sec$		$Q_{120\%}=2.290m^3/sec$	
	(m)	(m)	(El.m)	(m)	(m)	(Wl.m)	(m)	(Wl.m)
NO.0	0.00	0.000	45.800	6.000	0.380	46.180	0.453	46.253
+6.000	6.000	6.000	45.800	6.000	0.374	46.174	0.449	46.249
+12.000	6.000	12.000	45.788	6.000	0.383	46.171	0.458	46.246
+22.000	10.000	22.000	45.768	6.000	0.399	46.167	0.475	46.243
+32.000	10.000	32.000	45.748	6.000	0.415	46.163	0.492	46.240
+42.000	10.000	42.000	45.728	6.000	0.432	46.160	0.510	46.238
+52.000	10.000	52.000	45.708	6.000	0.449	46.157	0.527	46.235
+62.000	10.000	62.000	45.688	6.000	0.467	46.155	0.545	46.233
+72.000	10.000	72.000	45.668	6.000	0.485	46.153	0.564	46.232
+82.686	10.690	82.686	45.647	6.000	0.504	46.151	0.583	46.230
+92.686	10.000	92.686	45.627	6.000	0.523	46.150	0.602	46.229
+97.686	5.000	97.686	45.617	6.000	0.532	46.149	0.611	46.228
NO.1	2.314	100.000	45.390	6.514	0.769	46.159	0.941	46.240
NO.1+6.686	6.690	106.686	44.736	8.000	1.429	46.165	1.810	46.246
NO.1+16.686	10.000	116.686	44.636	8.000	1.529	46.165	1.910	46.246
NO.1+26.686	10.000	126.686	44.536	8.000	1.629	46.165	2.010	46.246
NO.1+36.686	10.000	136.686	44.436	8.000	1.729	46.165	2.110	46.246
NO.1+46.686	10.000	146.686	44.336	8.000	1.829	46.165	2.210	46.246
NO.1+56.686	10.000	156.686	44.236	8.000	1.929	46.165	2.310	46.246
NO.1+58.360	1.674	158.360	45.586	8.000	0.571	46.157	0.651	46.237
NO.1+68.360	10.000	168.360	45.576	8.000	0.580	46.156	0.660	46.236
NO.1+78.313	9.953	178.313	45.566	8.000	0.589	46.155	0.669	46.235
NO.1+87.313	9.000	187.313	45.557	4.000	0.568	46.125	0.645	46.202
NO.1+96.313	9.000	196.313	45.548	4.000	0.573	46.121	0.650	46.198
NO.2	3.687	200.000	45.544	3.631	0.579	46.123	0.655	46.199
NO.2+6.313	6.313	206.313	45.538	3.000	0.564	46.102	0.643	46.181
NO.2+16.313	10.000	216.313	45.528	3.000	0.563	46.091	0.643	46.171
NO.2+26.313	10.000	226.313	45.518	3.000	0.562	46.080	0.643	46.161
NO.2+36.236	9.920	236.236	45.508	3.000	0.561	46.069	0.643	46.151

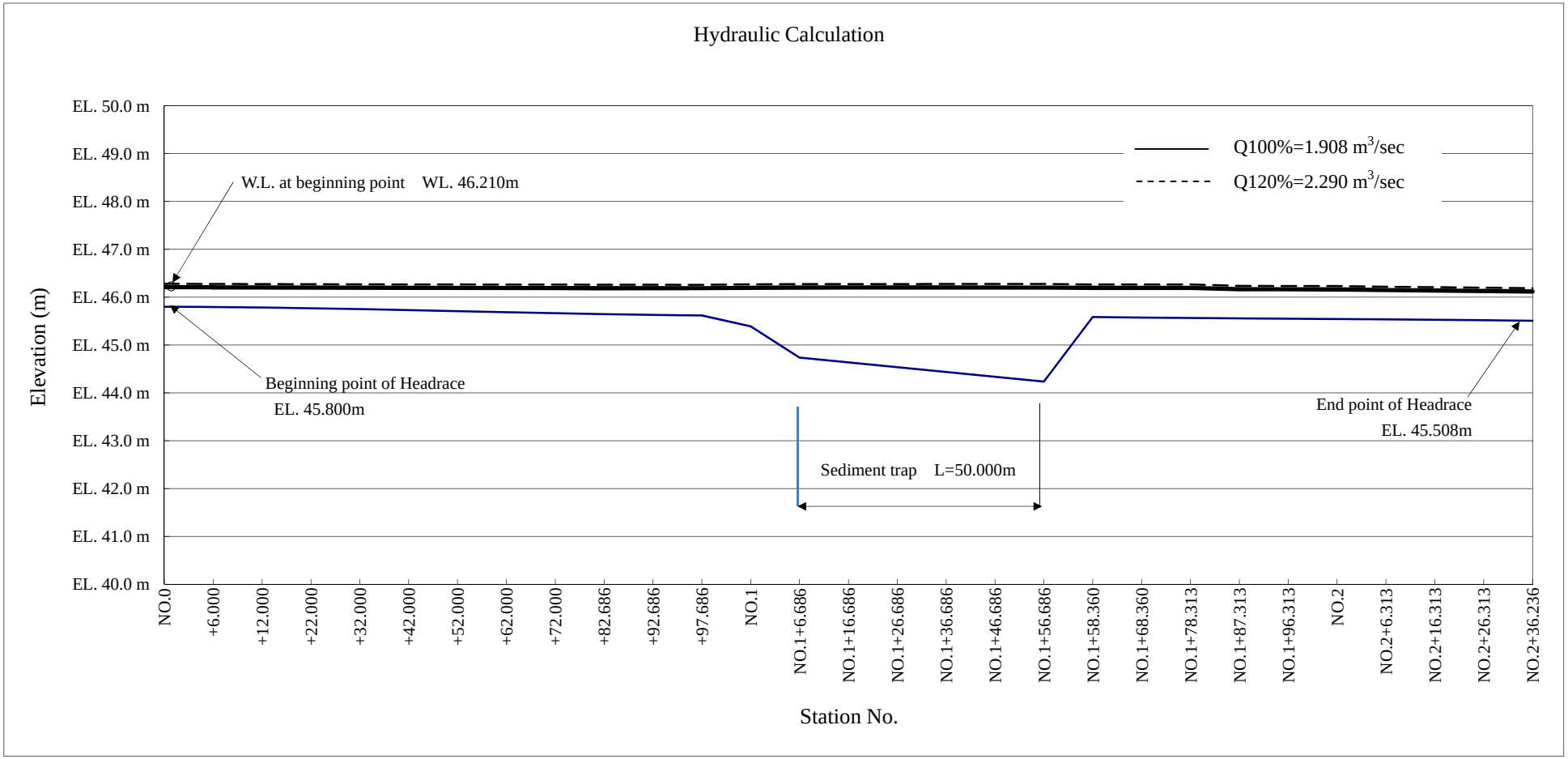


Figure 2-19 Hydraulic Profile of Headrace of Intake Canal

(10) Foundation Improvement Work for Canal

According to the results of the field investigation, the foundation ground of the headrace and the sediment trap consists of sand and gravel with boulders overlaid by not compacted sand and gravel with a thickness of 2m or more (EL.44.0m) from the present ground surface. Since the bottom elevation of headrace is EL. 45.5m at the upstream to EL.45.2m at the downstream, the foundation ground with a thickness of 1.5-2.0m was planned to be replaced by the soil material with good grain distribution. The earth work volume was estimated at about 3,300m^3, if the construction width is assumed as 10m. The riverbed deposit at the left bank of the intake structure is acceptable for the replacement material. The present sand and gravel containing boulders will be acceptable for the foundation ground for the sediment trap (L=50m) from the viewpoint of settlement, etc.

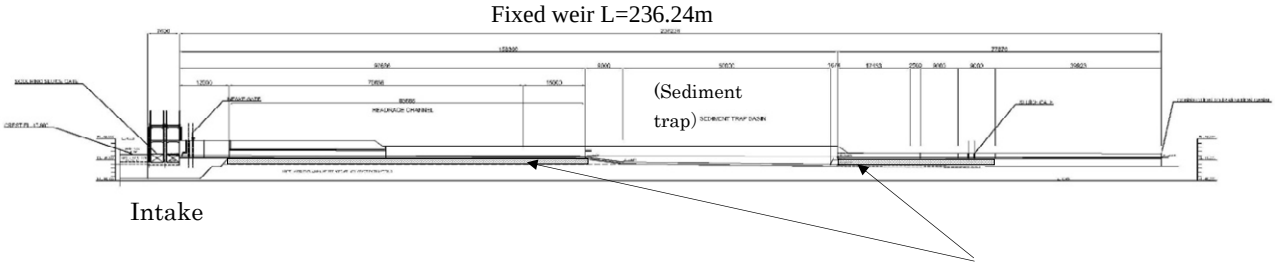


Figure 2-20 Foundation Improvement

(11) Riverbed Protection Work

In planning a fixed weir, the riverbed protection work is generally provided immediately below the downstream apron of the fixed weir in order to protect the downstream apron from the damage by the scouring. In this Project, however, it is judged financially and technically difficult for the Government.

The agencies of Timor-Leste need to carry out frequent reconstruction works of such damages. It is, therefore, judged that the riverbed protection work would not be applied to this Project after the study of the following conditions:

1) Large scale hydraulic jump will not be anticipated because the downstream water level in the flood time is higher than the weir crest. Accordingly, the water flow is not so turbulent.
2) Lowering trend of the riverbed is not expected though the riverbed scouring occurs temporarily. The possible occurrence of scouring which affect the apron structure is less.[1]
3) If the riverbed protection work is not applied, the impact to the apron will be questioned. However, this issue is expected to overcome by application of a downstream cut off with a depth of 4m, which was designed against 1.5 to 2.0m deep cut off required by the estimated scouring depth by the calculation for the flood.

[1] *The sedimentation develops toward upstream of the weir for 1-2 year after the construction, and soil and sand supply to the downstream reduces. However, in mid-long term, soil and sand are supplied to the downstream and serious riverbed degradation will not occur. Since the road rehabilitation project between Dili and Baucau is started from 2014, it is necessary to strictly notify to the related agencies to control the sand collection from this river.*

4) According to the design criteria for check (sabo)[2] dam, the riverbed protection work is not always required but required only where the possibility of scouring is high or water drop is large.

The following photographs show the riverbed protection works in November 2012 completed in 2011 under Bevui irrigation facilities located in the southern district of Manatuto-Baucau District where the present project is on-going.

Although the riverbed protection work is 1m cube, it is entirely damaged. It is because of that after the scouring depth of the riverbed reached more than 1 m, the riverbed protection block started from the downstream end of the apron one by one towards the upstream. The hydro-meteorological conditions of Bevui and Buluto projects are similar and the scale of intake weir is also almost similar. This is the reason that the cut off with a depth of 4.0m was applied and the riverbed protection was not applied.

Irrigation Facilities, Bevui Irrigation Project
The riverbed protection work was entirely damaged in one rainy season. According to the interview result, the overflow depth of the weir crest is about 1.0m. Therefore, the riverbed protection work was damaged by relatively a small flood.

There is an opening with a height of 20cm beneath the riverbed protection. Therefore, the scouring depth reached about 1.2m.

The scouring depth of the weir downstream in the flood is estimated at 1.5m~2.0m. The cutoff depth is therefore designed as 4.0m.

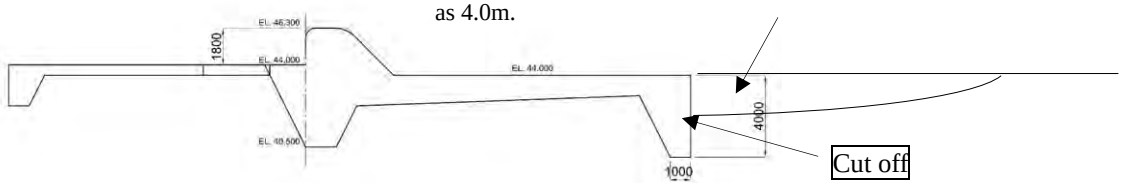


Figure 2-21 Cross Section of Fixed Weir

(12) Protection of Concrete Abrasion

The surface of the fixed weir, the downstream apron and the scouring sluice canal are worn away by flowing boulders and gravels. The countermeasures include application of the high strength concrete and protection by steel plate or stones. Timor-Leste has experience in steel plate and stone protection.

[2] *References: Design manual of civil engineering work (Sabo by Yamanashi Pref.) and Design criteria*

The high strength concrete was used in Mariana Irrigation . Stone protection is also used in Japan. The design is determined considering strength, resistivity and easy operation and maintenance.

Table 2-16 Protection Method of Concrete Abrasion

	Method	Feature	Experience
1.	High strength concrete	More cement with smaller water/cement ratio and rich concrete are applied. It is possible to apply Fc=40N/mm^2 (normally Fc=21N/mm^2). The protectiveness is 1/5 compared with stone protection. There are many experiences.	
2.	Steel plate protection	The steel plate is fixed with concrete by welded anchor bolt. Fixing anchor bolt and control temperature stress is required. High cost.	
3.	Stone Protection	Quality stones are required. Construction work is difficult, if employment of masonry is difficult and where the volume of work is large. It is possible to purchase such stones from Protection work was damaged by r20cm×20cm×H30cm in Timor-Leste.	
4.	Rubber steal method	Rubber steel is concrete protection material with both elasticity of rubber and strength of steel with a thickness of 30mm which can be replaced because of fixing by bolts. Attention must be paid to the tolerance against ultraviolet rays. High cost.	

The protection method was planned considering the above mentioned comparison.

Table 2-17 Protection Work for Concrete Abrasion

	Location of the work	Applied method
1.	Body of fixed weir	High strength concrete
2.	Downstream apron of the fixed weir	High strength concrete
3.	Downstream of scouring sluice*[1]	Steel plate protection
4.	Other concrete surface（Lower end of gate pier, Corner of guide wall, bank protection wall and downstream connection of fixed weir.	Steel plate protection

*1 : There are less boulders and gravels flushed in scouring sluice canal because of screen with 15 cm of space installed at the upstream. However, concrete surface is warned away by high velocity at the immediate downstream of the scouring sluice. Therefore, the downstream portion of the scouring sluice is planned to be covered by steel plate.

(13) Headrace Canal for Beneficiary Area in the Left Bank

Irrigation water shall be supplied to the Wenoren traditional irrigation system which extends at the left bank and the downstream of the diversion weir. The headrace is planned by a pipe canal and connects from the sediment trap to the left bank via. fixed weir. The pipe canal is constructed up to the immediate downstream of the diversion weir or along with the guide wall (200 m from the dam axis). The maximum intake discharge is 0.112 m^3/sec for 40ha (0.096 m^3/sec for 40ha in rainy season, and 0.112 m^3/sec for 40hain the dry season).

(At present, an existing open canal with a length of 1,200m in total connects from the downstream of the weir to the benefitted area. However, about 100m of the intermediate point was damaged by the slope failure of the natural ground. The study team has informed to MAF that this damage shall be repaired by MAF, and MAF has well understood to repair the damage.)

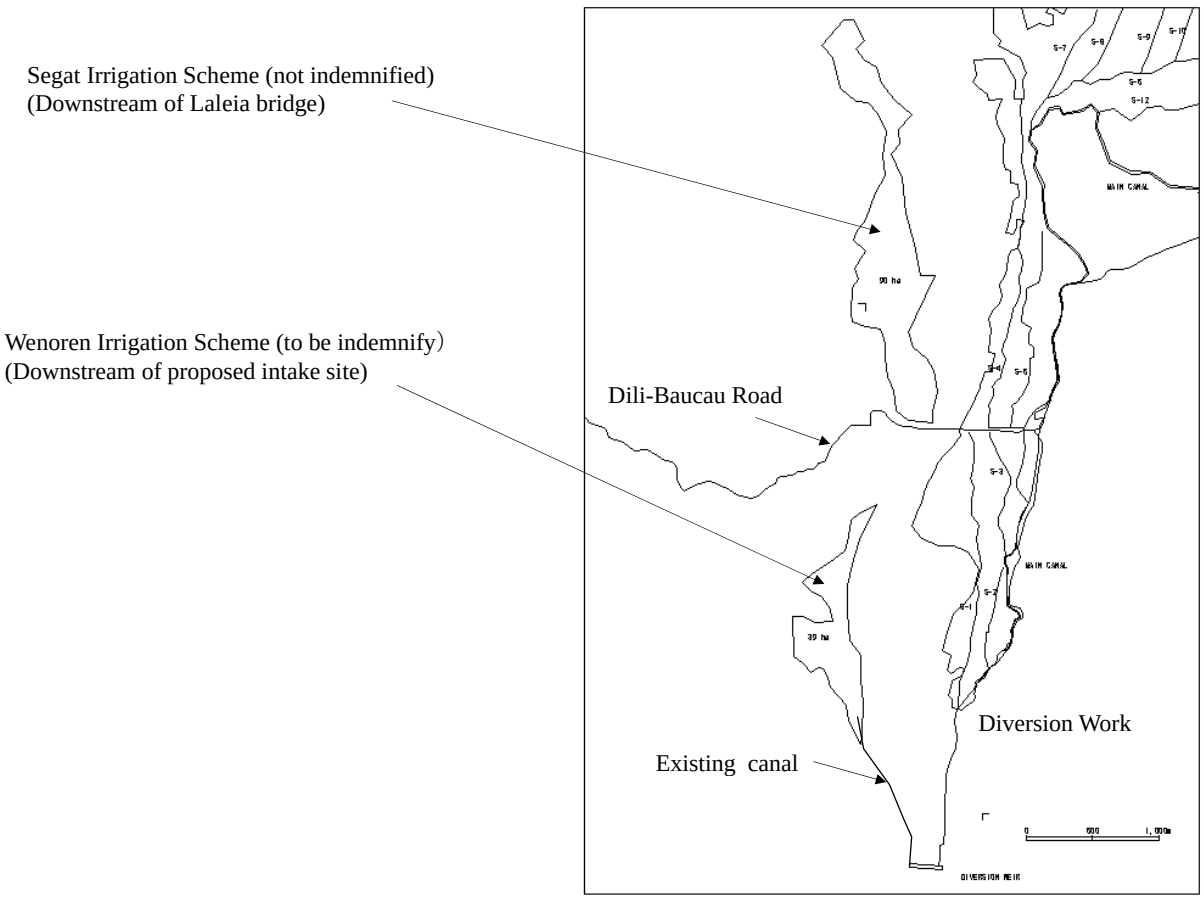


Figure 2-22 Location Map of Diversion Work for Traditional Irrigation Scheme

(14) Outlet on Fixed Weir Crest

Segat Irrigation Scheme which is an existing traditional irrigation system with an irrigation area of 90 ha extends at the left bank and 8km downstream of the Head Works and located at the downstream of Dili-Baucau road. It is necessary for MAF to clearly show the benefitted farmer in the Segat System the diverted discharge from the view point of the compensated irrigation water right. An outlet was, thus, designed on the weir crest for the downstream farmers in Segat to visibly confirm the discharge for them. The location of the outlet with a size of 1.5m wide and 0.2m deep was designed on the weir crest at the right bank where the river main course become stable. The stop log slots shall be provided for the outlet in order to maintain full water level of the upstream, when it is necessary. The outlet discharge equation is as follows:

$$H = \left(\frac{Q}{C \cdot L} \right)^{2/3} = \left(\frac{0.112}{1.704 \times 1.5} \right)^{2/3} = 0.124m \rightarrow 0.2m$$

where: H : Overflow depth（Depth of the outlet、m）
C : Overflow coefficient（1.704）
L : Overflow width（m）

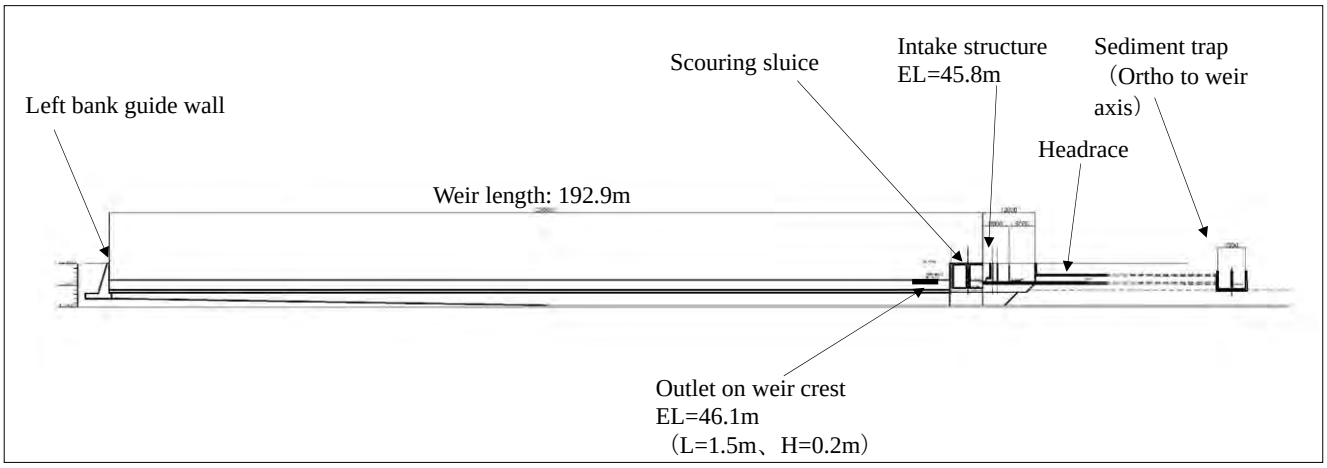


Figure 2-23 Profile of Weir Axis

The design parameter for the head works and the related facilities are outlined as follows:

Table 2-18　Description of Diversion Works

Facilities	Description of Facilities
Fixed weir	
・Weir type	Concrete Structure（Downstream weir slope= 1:1）
・Weir length	200m（including 7.1m for scouring sluice and piers）
・Weir height (upstream)	2m (44.3~46.3)
・Scouring sluice gate	2.5m（B）×2.1m（H）× 2spans（Sluice gate）
・Screen for scouring sluice	6.2m（B）×5.1m（H）（Steel screen）
Intake structure	
・Maximum intake discharge	2.5 m^3/sec （including left bank irrigation and 20% of allowance）
・Intake gate	1.50 m（B）× 0.8 m（H）× 4spans（Sluice gate）
Sediment trap	
・Structure	2 span with center partition wall, Reinforced concrete
・Length × Breadth	50 m × 8 m（4m×2spans）
・Capacity of sand trap	440 m^3
・Flush gate	2.0m（B）×1.2m（H）× 2spans（Sluice gates）
Headrace	
・Length	236.24 m（including sediment trap and transition canal
・Intake discharge control gate	2.0m（B）×0.75m（H）× 2spans（Sluice gates）
Bank protection guide wall	Semi-gravity retaining wall（both side of intake）H=9.6～8.1m（at weir axis）
Flood protection dike	Earth dike（Intake right bank upstream）H=7～8m（slope protection by masonry）
Gate control room*[1]	（5m×6m=30m^2）
Warehouse*[1]	（5m×6m=30m^2）
Others	
・Electric generator	Gate control room and were house
Left bank headrace	Installation of pipes

*[1] : 2.5refer to architectural planning

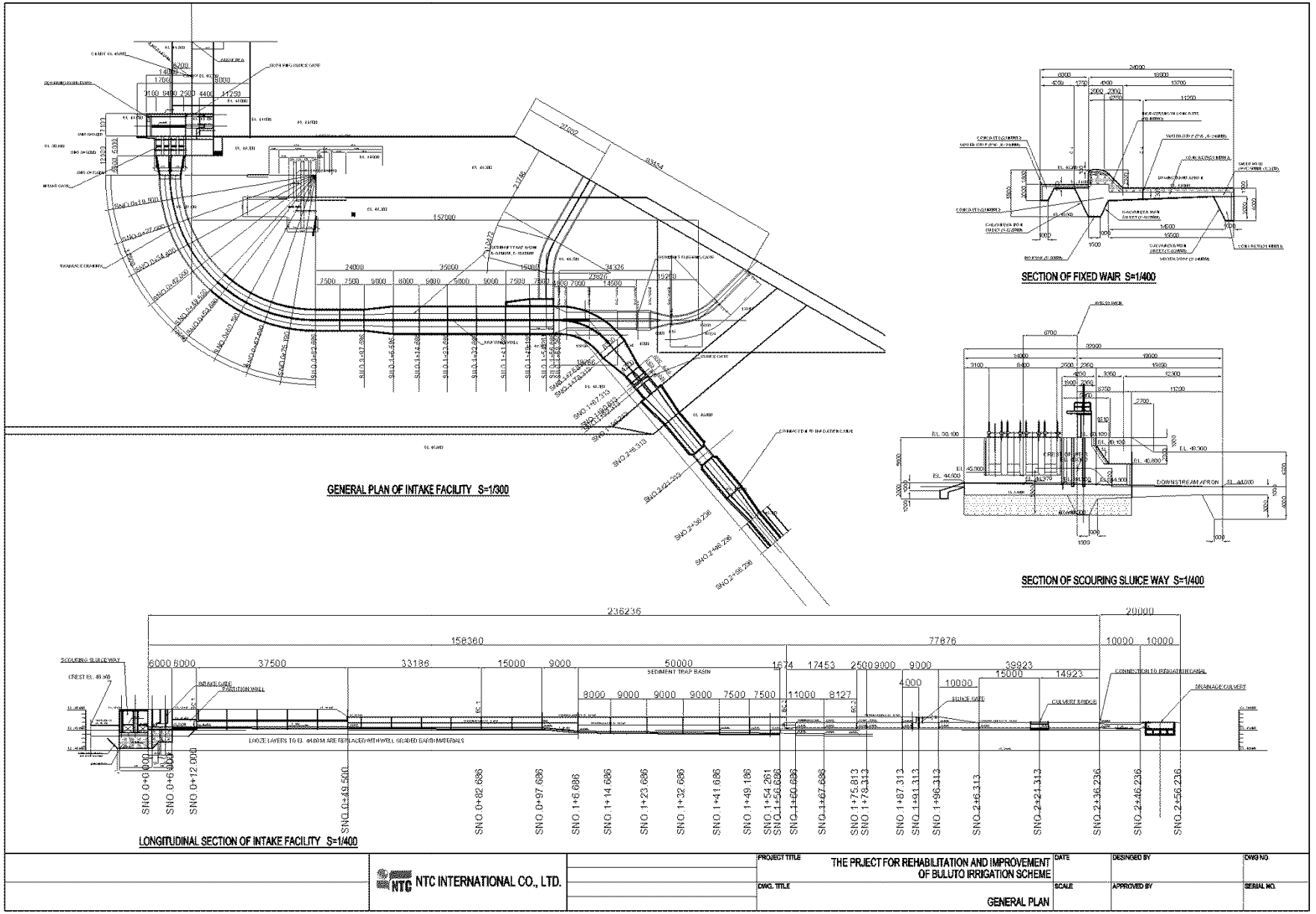


Figure 2-24 General Plan of Intake Structure

2-2-2-4 Irrigation Canal

(1) Irrigation Canal

The beginning point of the main canal is located at the end point of headrace canal (L=236m) connecting to the intake structure. The main irrigation with a length of 12.3km is divided into following two canals. The existing canal running along the beneficiary area is regarded as main canal for the upstream portion (7.7 km approximately), which will be used after improvement of the existing canal section. On the other hand, the downstream portion of the main canal (4.6 km approximately) will be newly constructed. Although, the land for the downstream main canal should be newly acquired, the lost farming area due to the main canal construction will be minimized as much as possible by constructing the canal in the existing wasteland or non-cultivated area along the road.

The secondary canals consist of 15 canals which divert from main canal and 1 canal divert from the secondary canal. New acquisition of the land for secondary canal was minimized, since the existing secondary & tertiary canal was planned to be used to the extent possible. The canal structure and its related facilities are as follows.

Table 2-19 Description of the Irrigation Canal Facilities

Item	Main Canal	Secondary Canal
Number of the canal	1 canal	16 canal
Length (Total)	12.3km	15.4km
Design discharge	1.92～0.11m^3/sec	1.17 ～0.11 m^3/sec
Structure of the canal	Wet masonry (trapezoidal) (Partly, wet masonry and concrete with rectangular section and box , respectively)	Earth canal with trapezoidal (Partly, box culvert is also constructed)
Related facilities	Division works Check gate Drop Inspection road Bridge (For crossing national road and canal) Drainage Spill way Emergency discharge facility	Division works Bridge (For crossing structure)

1) Main canal

The standard structure of main canal will be a trapezoidal section consisting of the side walls with wet masonry and bottom floor with plain concrete. The height & width of canal section will be designed to be appropriate size for the design discharge based on the calculation result. Wet masonry canal with trapezoidal edge section is the standard canal structure in Timor-Leste and is judged appropriate considering structural aspects. Based on the result of design discharge calculation, the shape of each canal section was designed. The canal with rectangular section and box culvert will also be used as necessary. The canal with rectangular section will be constructed with L=400m paddy field and farm land to reduce the earth work volume, since this portion requires

high embankment. The box culvert is constructed at the portion of L=500m running along the national road & residential area. In this span, the bottom altitude of the canal is about 2m lower than the original ground, which requires the large cutting width in constructing the canal with trapezoidal section. Moreover, the depth between bottom elevation of the canal and original ground as deep causes the falling risk. Therefore, the box culvert is designed to be used at this portion. All the canal section is designed to be appropriate structure for the canal maintenance towards the sedimentation. Table 2-20 and Table 2-21 show the standard section and specification of main canal respectively.

Table 2-20 Typical Section of Main Canal

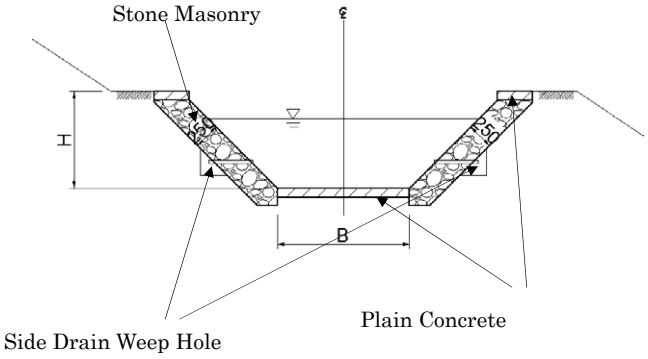
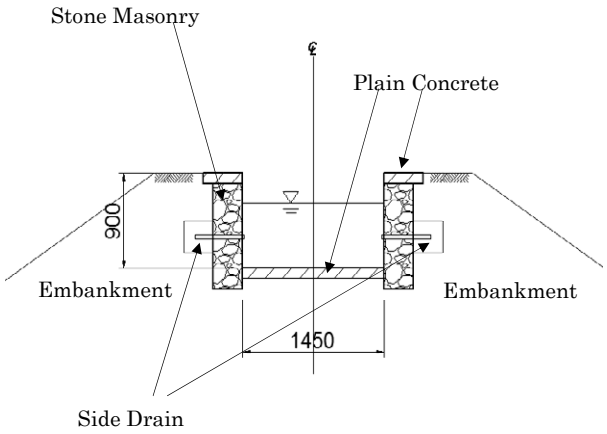
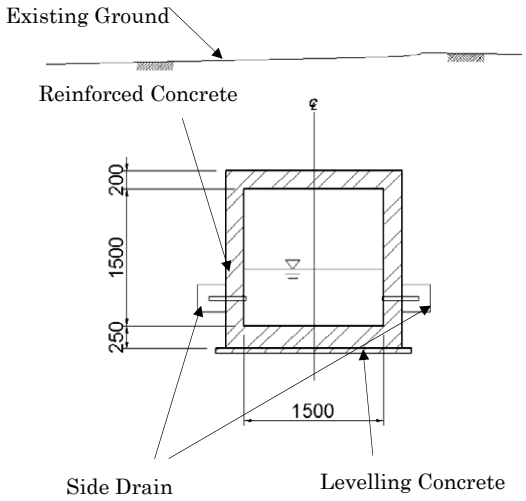
Typical Section	Remarks
The typical section for normal potions  	<u>Canal type :C2, C3, C4, C5, C6, C7, C8</u> Trapezoidal cross-section Canal made of the stone masonry and plain concrete. Section size is decided according to their necessarily water quantity. (cf. Table 2-21) Set the side drain to protect from the ground water. Section of C1 is the same canal type with C2. (cf. O&M road)
Rectangular Canal  	<u>Canal type :R1</u> Rectangular Canal made of the stone masonry and plain concrete. Install to the high embankment potion. Set the side drain to protect from the ground water.
Box Culvert Canal  	<u>Canal type :B1</u> Box Culvert Canal made of the reinforced concrete mainly. Install to the site of lower water head than existing ground level, next to national road, and high traffic area. Set the side drain to protect from the crack by ground water.

Table 2-21 Structural Specification of Main Canal

Canal Type	H(m)	B(m)	Distance(m)	Remarks
C1	1.10	1.50	1,090	Running along the new Maintenance road / Trapezoidal section
C2	1.10	1.50	1,910	Trapezoidal section
C3	1.00	1.50	2,798	ditto
C4	1.00	1.40	972	ditto
C5	0.90	1.25	1,350	ditto
C6	0.90	1.20	1,800	ditto
C7	0.90	1.00	750	ditto
C8	0.90	0.60	762	ditto
R1	0.80	1.45	400	The span of canal with rectangular section constructed in C6
B1	1.50	1.50	500	The span of canal with box culvert section constructed in C6
Total			12,332	10 types

2) Secondary Canal

The existing earthen canal will be used for the secondary canal, which requires repair work canal bed and slope. The height and width of the canal was decided based on the hydraulic calculation shown in Table 2-22. The canal is designed to be the same as existing earthen canal structure with trapezoidal section. However, several portions require the canal sections with deep cut. The box culvert was designed at the portion having a lot of resident's traffic while the canal in the rest of spans was designed as the earthen canal deep cut. Both the box culvert and earthen canal were designed so as to allow the maintenance works such as the removal of sediments.

Table 2-22 Dimension of Secondary Canal

Secondary Canal No.	H(m)	B(m)	Distance(m)	Remark
NO.1	0.55	0.40	2,556	
NO.2	0.35	0.40	850	
NO.3	0.45	0.40	1,220	
NO.4	0.50	0.60	1,459	
NO.5	0.65	0.60	1,083	
NO.6	0.40	0.40	389	
NO.7（Upstream）	0.55	0.60	258	The structure section varies depending on the flow volume in the upstream and the downstream side
NO.7（Downstream）	0.50	0.60	127	
NO.8	0.45	0.40	844	
NO.9	0.50	0.60	939	
NO.10	1.50	0.60	140	Box culvert
	1.50	0.60	484	Open canal deep cut
NO.11	1.50	0.60	100	Box culvert
NO.12（Upstream）	0.70	0.60	454	The structure section varies depending on the flow volume in the upstream and the downstream side
NO.12（Downstream）	0.60	0.60	876	
NO.13	0.60	0.45	1,317	
NO.14	0.40	0.55	989	
NO.15	0.55	0.40	650	
NO.16	0.55	0.40	665	
Total			15,400 m	

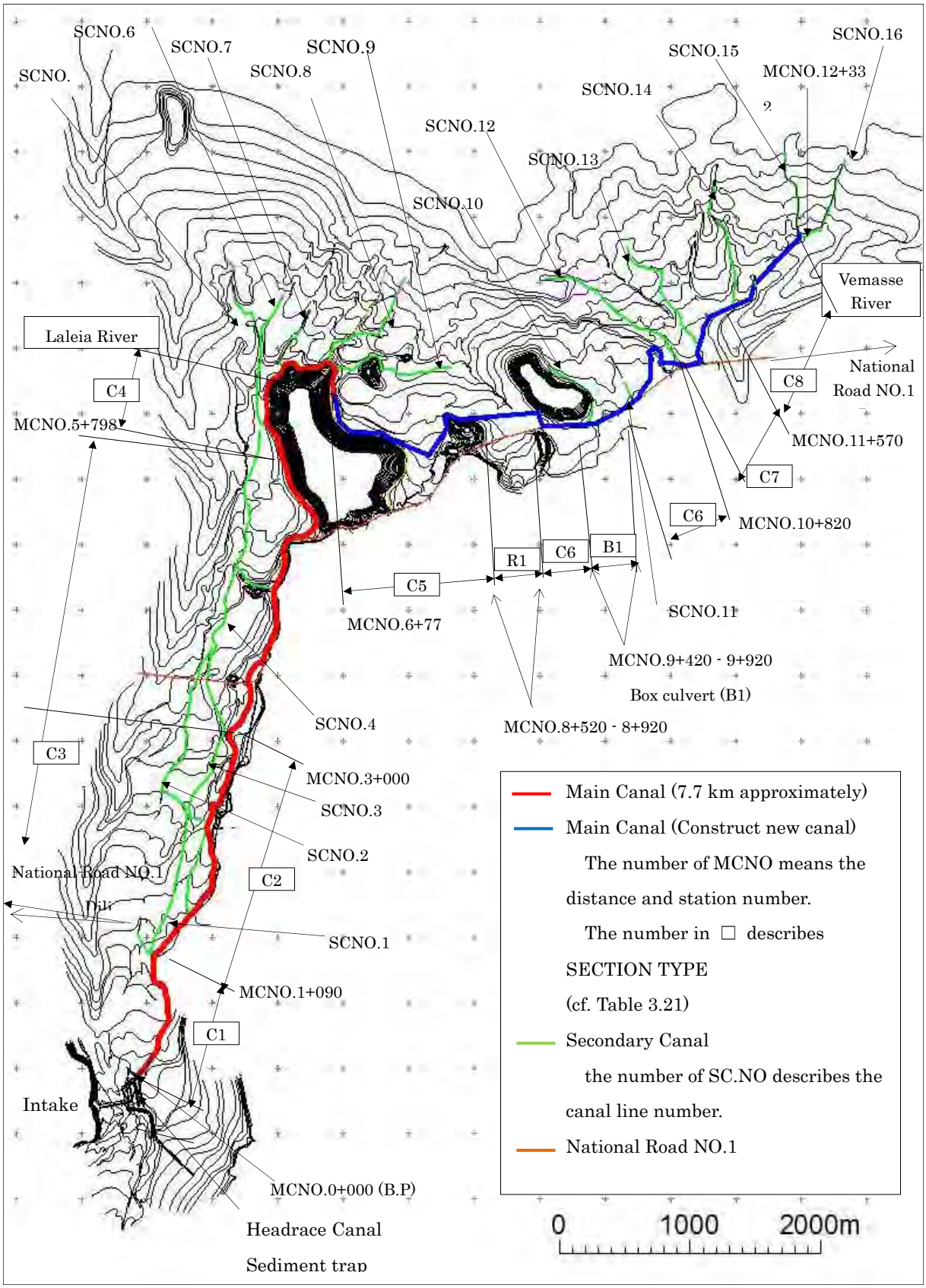


Figure 2-25 Site Map of Irrigation Canals

(2) Division Works

The gate-controlled division works will be constructed in water diversion points of 1) main canal to secondary canal, and 2) secondary canal to secondary canal. In the division works, the weir for the flow measurement will be additionally constructed to manage the water diversion properly. The gate size of division works are designed as the following two types.

a) 400mm (B) x 400mm (H) in case that the flow volume of branched canal is Q $\geqq$ 0.12 m^3/sec.

b) 300mm (B) x 300mm (H) in case that the flow volume of branched canal is Q < 0.12m^3/sec

Table 2-23 Gate Size of the Division Works

No. of division works	Main canal 50% water level m^3/sec	Intake discharge of secondary canal m^3/sec	Gate size
BL.1	0.502	0.145	400 × 400
BL.1a	0.502	0.004	300 × 300
BL2	0.502	0.027	300 × 300
BL.3	0.502	0.047	300 × 300
BL.4	0.502	0.067	300 × 300
BL.5	0.467	0.040	300 × 300
BL.6	0.467	0.073	300 × 300
BL.7	0.467	0.018	300 × 300
BL.8	0.467	0.020	300 × 300
BL.9	0.467	0.204	400 × 400
BL.10	0.477	0.126	400 × 400
BL.11	0.477	0.087	300 × 300
BL.12	0.477	0.134	400 × 400
BL.13	0.422	0.034	300 × 300
BL.14	0.422	0.038	300 × 300
BL.15	0.411	0.062	300 × 300
BL.16	0.411	0.102	300 × 300
BL.17	0.411	0.171	400 × 400
BL.18	0.341	0.135	400 × 400
BL.19	0.341	0.105	300 × 300
BL.20	0.341	0.108	300 × 300
BL.21	0.235	0.061	300 × 300
BL.22	0.235	0.111	300 × 300
Total			23 points

(3) Check Gate

The check gate will be installed at 5m downstream from the division works in main canal. The check gate will not be installed at BL22, because its division works is located at the most downstream side. The check gate size is classified into following 4 types depending on the canal section. (Source: USBR)

Table 2-24 Installation Numbers of Check Gates

Main canal section				Gate size B(mm) × H(mm)	Number
Wall height	100% Water level (m)	Bottom width (mm)	Crown width (mm)		
1100	0.791	1500	3500	2.00 × 0.90	4
1000	0.705	1500	3300	2.00 × 0.80	5
1000	0.719	1400	3200	2.00 × 0.80	3
900	0.636	1250	2850	1.75 × 0.70	2
900	0.620	1200	2800	1.75 × 0.70	3
800	0.514	900	2500	1.50 × 0.60	3
600	0.354	600	1600	1.50 × 0.60	1
					Total 21

(4) Drop Structure

The drop is classified into two types depending on the fall height of 1m and 0.5m. The structure of 1m fall height type has three sides of stretches with concrete, while that of 0.5m fall height type is made of wet masonry with reinforced concrete box. Its installation with the canal section will be adjusted by the transition zone. The hydraulic calculation of drop is carried out based on the drop works plan for stilling basin by referring the Japanese guide book of "Design standards for land improvement project: Part of canal works".

1) 1m Drop

1m drop was planned on the profile of main canal where all the height is 1m approximately. Several 1m drops will be installed if the fall height is more than several meters (4m at maximum). The structure of the drop will be designed as a water cushion type. The section size of drop will be adjusted to the main canal section. Besides, the water cushion part will be designed to have sufficient size for the energy dissipation of falling water. Figure 2-26 and Table 2-25 show the standard drawing of 1m drop and its dimension, respectively (Based on the Japanese guide book of "Design standards for land improvement project: Part of canal works").

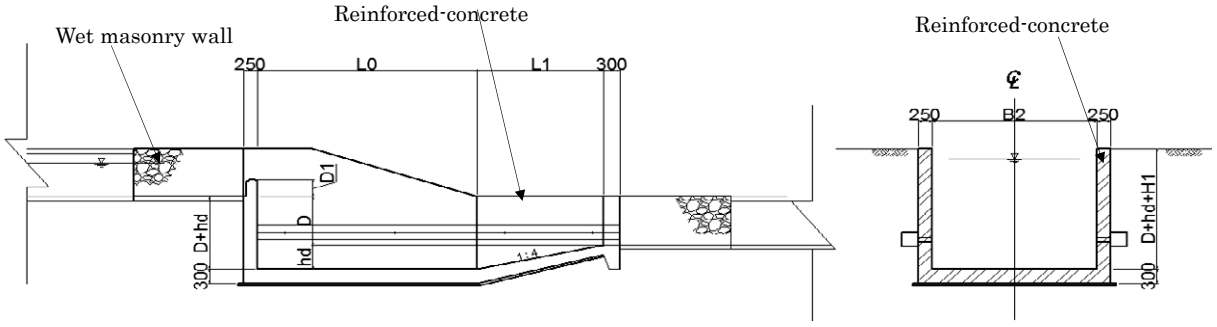


Figure 2-26 Standard Section of 1m Drop

Table 2-25 Dimension of 1m Drop

Canal type	B1	D1	hd	L0	L1	H1	Remarks／Canal section to be adjusted H(Crown height) × B(Base-width)
D1	2.00	0.13	0.60	3.90	2.40	1.10	1.10 × 1.50
D2	2.00	0.13	0.60	3.60	2.20	1.00	1.00 × 1.50
D3	1.50	0.13	0.40	3.60	2.20	1.00	1.00 × 1.40
D4	1.20	0.10	0.40	2.50	1.20	0.90	0.90 × 1.00
D5	1.20	0.10	0.40	1.60	1.20	0.60	0.60 × 0.60

2) 0.5m Drop

0.5m drop was planned on the profile of main canal where the fall height is 0.5m approximately. Energy dissipater of hydraulic jump type will be applied for the drop structure. The section size of drop will be adjusted to the main canal section. Besides, the apron length in the downstream will be designed to have sufficient size for the energy dissipation of falling water. Figure 2-27 and Table 2-26 show the standard drawing of 0.5m drop and its dimension (Based on the Japanese guide book of “Design policies for land improvement project: Part of Reservoir development”).

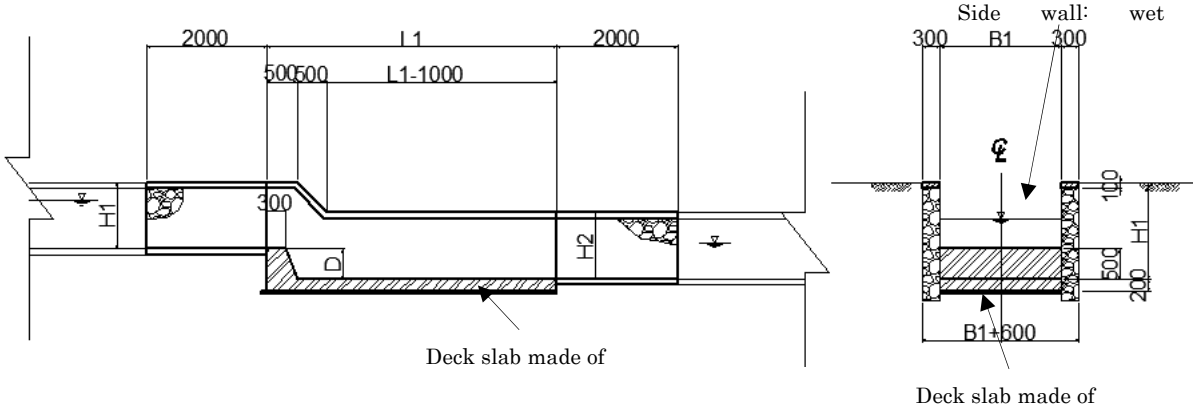


Figure 2-27 Standard Section of 0.5m Drop

Table 2-26 Dimension of 0.5m Drop

Canal Type	B1	L1	Remarks／Canal section to be adjusted H(Crown height) × B (Base-width)
D6	2.00	4.80	1.10 × 1.50 (Planned water depth 1.10m)
D7	2.00	4.80	1.10 × 1.50 (Planned water depth 1.00m)
D8	2.00	4.50	1.00 × 1.50
D9	1.50	4.50	1.00 × 1.40
D10	1.20	3.20	0.90 × 1.00
D11	1.20	2.10	0.60 × 0.60

(5) Maintenance Road

The Maintenance road was planned along the main canal for the O&M. The maintenance road will

not be newly constructed, if there is existing maintenance road or existing public road available for the O&M activities. In particular, although the downstream of main canal (L=4.5km) will be newly planned, the new maintenance road will not be constructed, since the canal alignments will be planned along the existing national road, which can be used as a maintenance road. The section of road is shown in Figure 2-28.

Presently, there are few maintenance roads along the secondary canal in the Project area. Although the distance from the farm to the national road is 2.0km at the maximum, the farmers carry the harvested crops to the national road by themselves, as they walk on the edge of secondary canal and paddy field dike. Thus, the edges and dikes will be regarded as maintenance road for the secondary canal meaning that the new construction of the maintenance road will not be required to avoid losing farm area by its construction.

Crushed stone pavement type with a width of 3.5m will be applied to the maintenance road. Newly planned maintenance road (1.3 km from the weir along the main canal) is not only for the canal O&M, but also for the O&M of the head works. Thus, the total width of the road is designed as 4.5m including 0.5m width of road shoulder in both the road sides, on the assumption that there is a passing of the large truck (6t) on the road. Furthermore, 0.5m wide soft shoulder was designed in between the road and the canal crown (Based on the Japanese guide book of "Design criteria for land improvement project: Part of farm road)

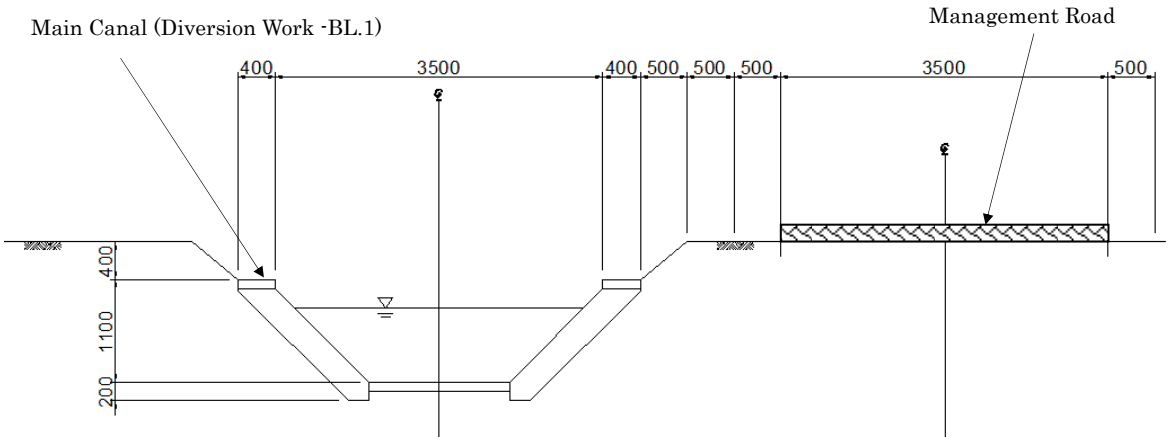


Figure 2-28 Standard Section of Maintenance Road

Table 2-27 Length of Maintenance Road

Item	Maintenance road (utilization of existing road)	Maintenance road (New establishment)
Length	11.0 km	1.3 km

(6) Bridge

The bridge will be established in several places, where the road crosses the canal. The bridge is classified into 2 types, namely national road crossing bridge and canal crossing bridge. Canal crossing bridge will be planned in every 500～1000 m interval depending on the house distribution condition. Table 2-29 and Figure 2-31 show the list of bridge location and the location of bridge, respectively.

1) National Road Crossing Bridge

The national road crossing bridge will be established in the crossing point (Laleia side) of National Road No.1 and the main canal. Although the traffic volume of National Road No.1 is not much, the width of the bridge will be 5.0m, since the large truck passes on the road. The bridge was designed as box culvert structure. Besides, the height of wheel guard was designed as 30cm (Based on Enactment by Ministry of Land, Infrastructure and Transport "Standard design of civil engineering structure" Part of Box culvert work (T-25)). Figure 2-29 shows the standard section of National road crossing bridge.

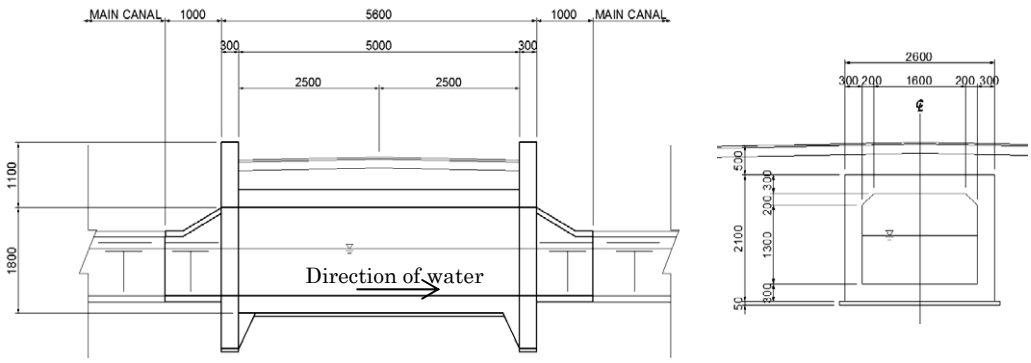


Figure 2-29 Standard Section of National Road Crossing Bridge

2) Canal Crossing Bridge

Canal crossing bridge was planned at the places where the residents, vehicles and farm implements need to cross the canal. The width of bridge will be 3.0m for the passage of vehicles. The bridge was designed as the box culvert structure with reinforced-concrete. Besides, 30 cm height of the wheel guard will be installed in the bridge (Based on "Design criteria for land improvement project No.2": Part of reinforced-concrete canal (T-14)). Figure 2-30 shows the standard section of canal crossing bridge. The connection between the bridge and canal will be adjusted by the transition zone. Moreover, the surface structure of the culvert was designed as 15cm of base course and 3cm of asphalt surface course.

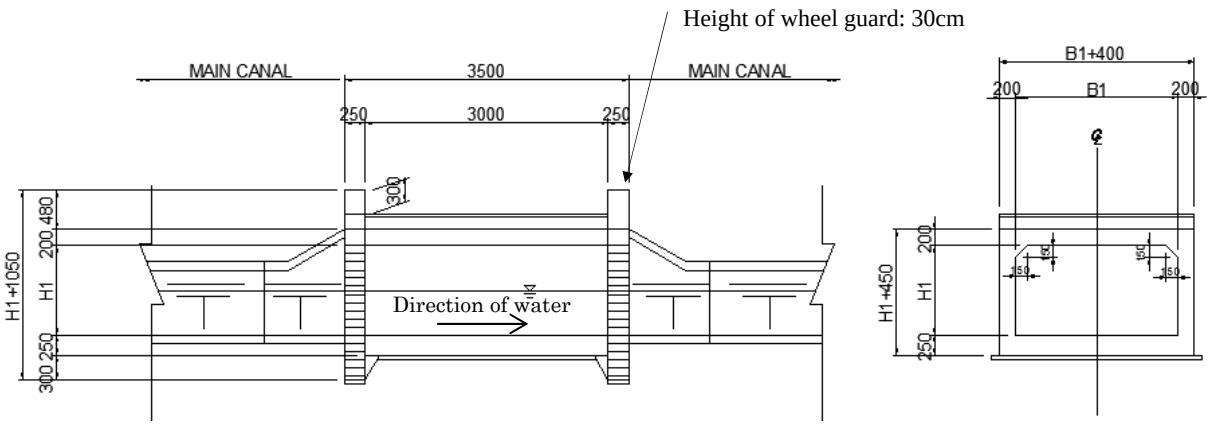


Figure 2-30 Standard Section of Canal Crossing Bridge

Table 2-28 Dimension of Canal Crossing Bridge

Type No.	B1(m)	H1(m)	Remarks／Canal section H(Crown height)x B（Base-width）
B2	2.00	1.10	1.1 × 1.5 ～ 1.0 × 1.5
B3	1.50	1.00	1.0 × 1.4 ～ 0.9 × 1.2
B4	1.20	0.90	0.9 × 1.0 ～ 0.6 × 0.6
B5	1.50	1.50	3 bridges were planned in the upstream side of Box culvert main canal (500m) The section of canal crossing bridge is the same structure as the box culvert main canal.

Table 2-29 List of Locations of the Bridge

Position No.	Survey station	Type No.	Remarks
National Road crossing bridge	MCNO.3+511	B1	Main canal
1	MCNO.1+090	B2	〃
2	MCNO.1+472	B2	〃
3	MCNO.2+175	B2	〃
4	MCNO.3+146	B2	〃
5	MCNO.4+264	B2	〃
6	MCNO.4+896	B2	〃
7	SC05.0+010	B4	Secondary canal
8	-	B4	Planned at diverted tertiary canal from BL.8
9	MCNO.5+970	B3	
10	MCNO.6+270	B3	〃
11	MCNO.6+720	B3	〃
12	SC08.0+240	B4	Secondary canal
13	MCNO.6+920	B3	
14	MCNO.7+520	B3	〃
15	MCNO.8+270	B3	〃
16	MCNO.9+020	B3	〃
17	MCNO.9+220	B5	〃
18	MCNO.9+270	B5	〃
19	MCNO.9+320	B5	〃
20	MCNO.11+270	B4	〃
21	MCNO.11+570	B4	〃
22	MCNO.11+820	B4	〃
23	MCNO.12+270	B4	〃

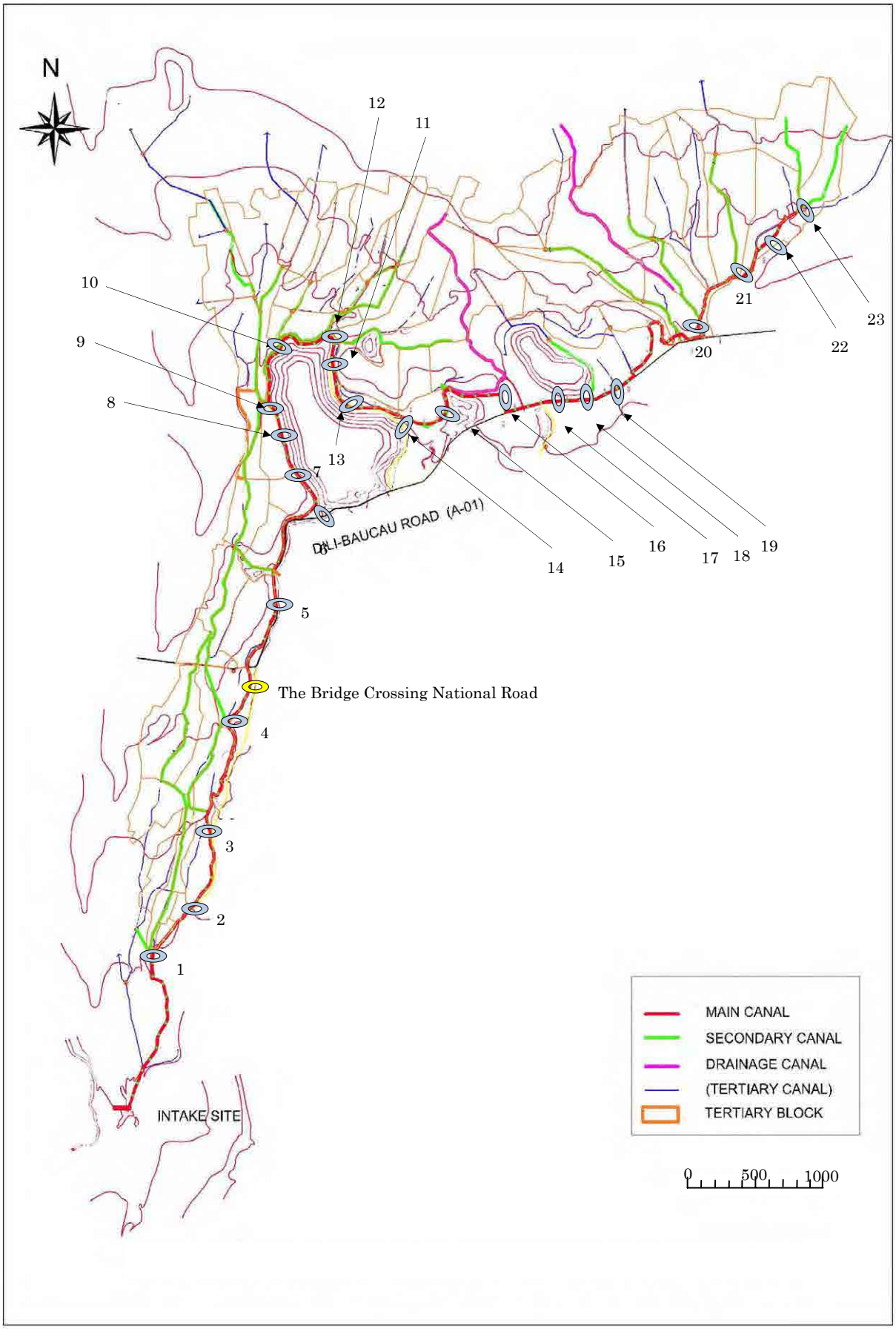


Figure 2-31 Site Map of Bridges

7) Canal Crossing Drainage Work

The drainage basin along the main canal is shown in Figure 2-32. The drainage discharge of each drainage basin was calculated by the rational runoff formula with following numerical values. Concentration time of drainage : 0.5 hours, 2 years probable rainfall intensity: 45.2 mm/hr, Runoff coefficient: 0.25. The unit area drainage discharge is 3.1 $m^3/s/km^2$ according to the calculation. The design drainage discharge is shown in Table 2-30, while the rainfall intensity and the runoff coefficient are shown in Table 2-8 and 2-9, respectively.

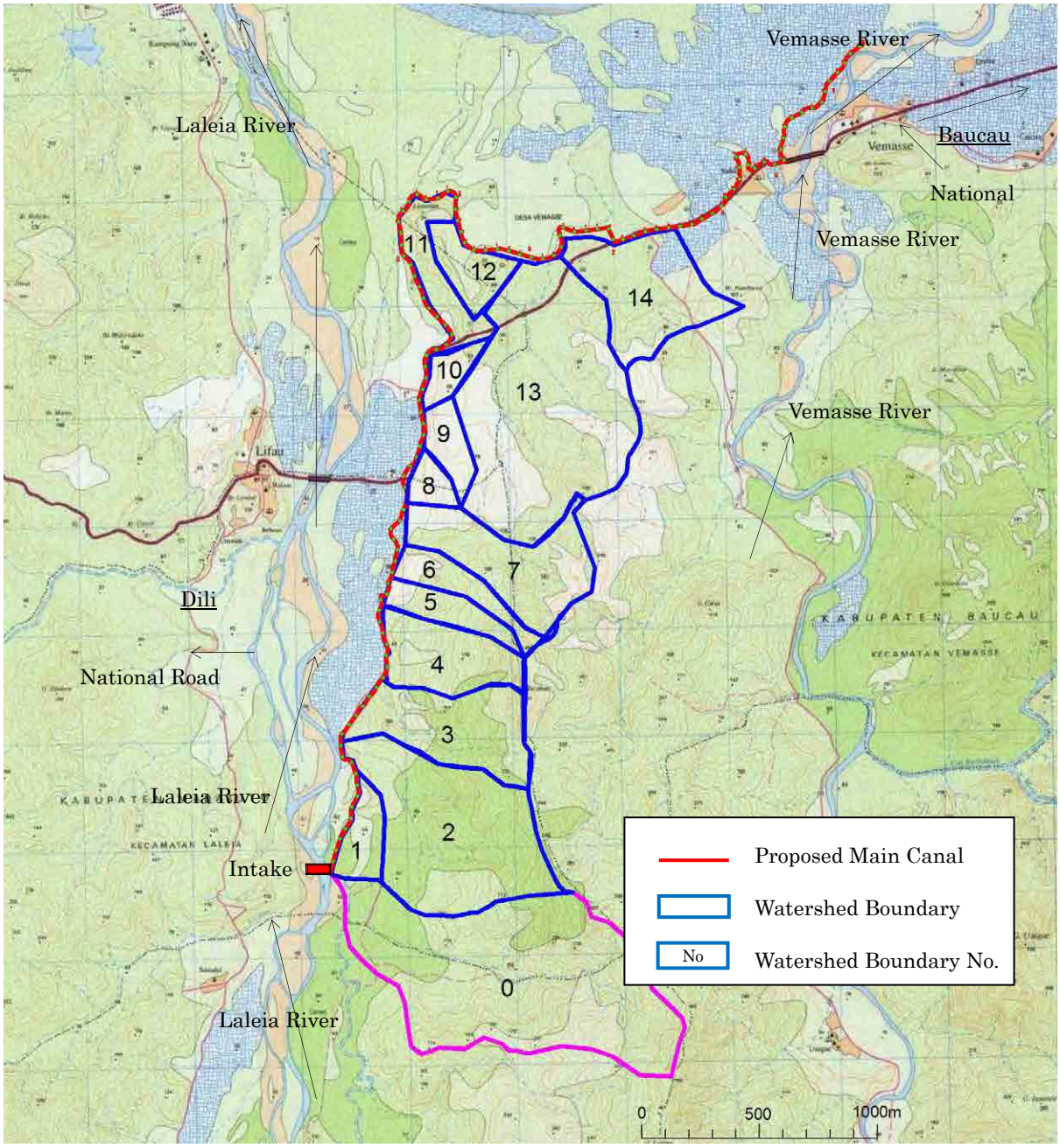


Figure 2-32 Watershed Boundary for the Drain Structure Crossing the Main Canal

Table 2-30 Drainage Basin Area and Design Drainage

Drainage basin No.	Station No.			Drainage area (km^2)	Drainage Discharge (m^3/s)
0	Around intake			2.99	9.27
1	0+000	to	0+605	0.40	1.24
2	0+605	to	0+995	1.57	4.87
3	0+995	to	1+675	0.88	2.73
4	1+675	to	2+280	0.62	1.92
5	2+280	to	2+567	0.28	0.87
6	2+567	to	2+858	0.30	0.93
7	2+858	to	3+495	0.91	2.82
8	3+495	to	3+814	0.14	0.43
9	3+814	to	4+114	0.23	0.71
10	4+114	to	4+665	0.16	0.50
11	4+665	to	6+720	0.40	1.24
12	6+720	to	7+720	0.25	0.78
13	7+720	to	8+370	2.27	7.04
14	8+370	to	9+420	0.88	2.73

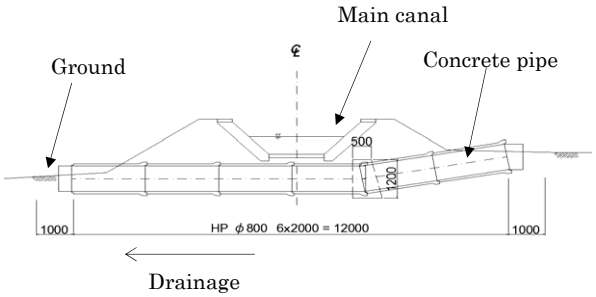
i) Canal Crossing Drainage Work

Drainage work will be constructed at the exit of the drainage catchment area or at the place where there is the existing drainage canal. Besides, the canal crossing bridge will be utilized as drainage work as well, if the wastewater is drained by surface drainage of canal crossing bridge.

The drainage pipe culvert work, the drainage box culvert work and the drainage aqueduct river will be constructed for the rest of the places requiring the drainage works. Totally 4 types of the drainage works will be constructed in the proper place with consideration on the canal bed height, the ground level and the size of drainage works. Table 2-31 shows the type of drainage canal while the location map of drainage works in each catchment area is shown in Table 2-32.

Table 2-31 List of Drainage Work Types

Pipe culvert drainage work



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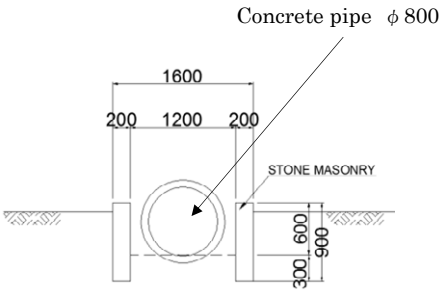
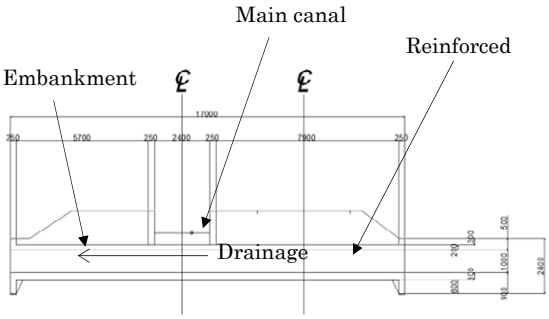


Cross-section

Box culvert drainage work



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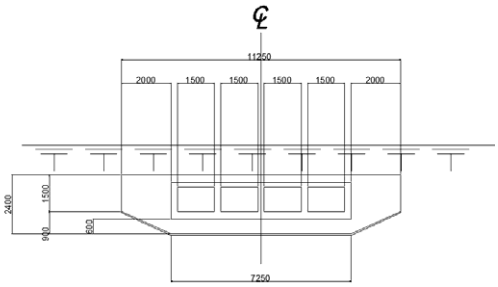
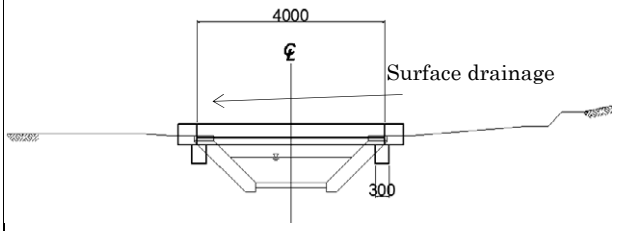
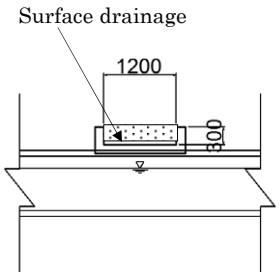


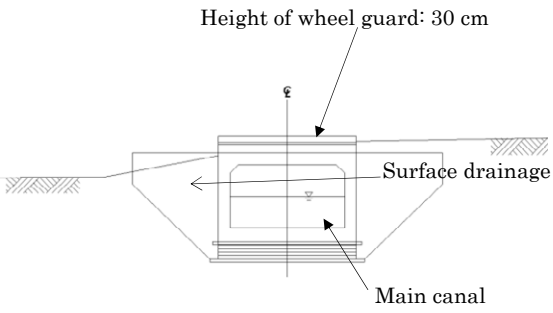
Cross section (Four in low)

Drainage work of canal bridge





Surface drainage aqueduct



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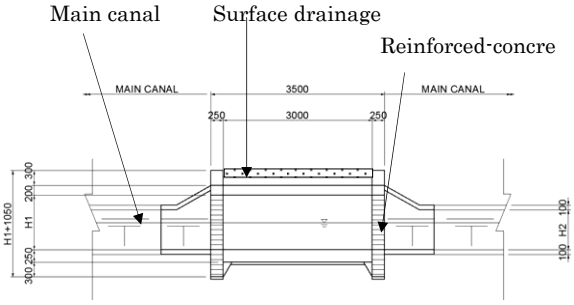


Cross section

ii) Drainage plan

According to the topographical condition and the vertical alignment of main drainage canal, the drainage plan of each catchment area is decided as shown in Table 2-32.

Table 2-32 Specification of Drainage Works

Position No.	Measuring Point	Drainage section	Drainage work structure	Catchment No.
1	0+457	φ800×3	Pipe culvert drainage work	1
2	0+870	B1.50m × H1.00m × Four	Box culvert drainage work	2
3	1+472	φ800×1	Pipe culvert drainage work	3
4	1+675	B1.50 × H1.00 × dabble	Box culvert drainage work	
5	1+914	φ800×2	Pipe culvert drainage work	4
6	2+119	φ800×2	Pipe culvert drainage work	
7	2+232	φ800×2	Pipe culvert drainage work	
8	2+282	φ800×1	Pipe culvert drainage work	5
9	2+525	φ800×1	Pipe culvert drainage work	
10	2+641	φ800×1	Pipe culvert drainage work	6
11	2+858	φ800×1	Pipe culvert drainage work	
12	3+000	φ800×2	Pipe culvert drainage work	7
13	3+146	B1.2m × H0.3m	Drainage canal bridge	
14	3+348	B1.2m × H0.3m	Drainage canal bridge	
15	3+495	B1.2m × H0.3m	Drainage canal bridge	
16	3+585	B1.2m × H0.3m	Drainage canal bridge	8
17	3+767	B1.2m × H0.3m	Drainage canal bridge	
18	3+914	B1.2m × H0.3m	Drainage canal bridge	9
19	4+016	B1.2m × H0.3m	Drainage canal bridge	
20	4+164	B1.2m × H0.3m	Drainage canal bridge	10
21	4+483	B1.2m × H0.3m	Drainage canal bridge	
22	4+896	B1.2m × H0.3m	Drainage canal bridge	11
23	5+097	B1.2m × H0.3m	Drainage canal bridge	
24	5+497	B1.2m × H0.3m	Drainage canal bridge	
25	5+697	B1.2m × H0.3m	Drainage canal bridge	
26	6+020	B1.2m × H0.3m	Drainage canal bridge	
27	6+220	B1.2m × H0.3m	Drainage canal bridge	
28	6+470	B1.2m × H0.3m	Drainage canal bridge	
29	6+970	B1.2m × H0.3m	Drainage canal bridge	12
30	7+220	B1.2m × H0.3m	Drainage canal bridge	
31	8+220	B1.5m × H1.0m × triple	Box culvert drainage work	13
32	8+720	φ800×2	Pipe culvert drainage work	14
33	8+920	φ800×2	Pipe culvert drainage work	
34	9+220	φ800×2	Pipe culvert drainage work	

※See the position list of the canal crossing bridge as a reference of surface drainage canal crossing bridge

Table 2-33 Site Number of Drainage Construction

Drainage work structure	Amount Number
Pipe culvert drainage	3
Box culvert drainage	23
Canal bridge drainage	18

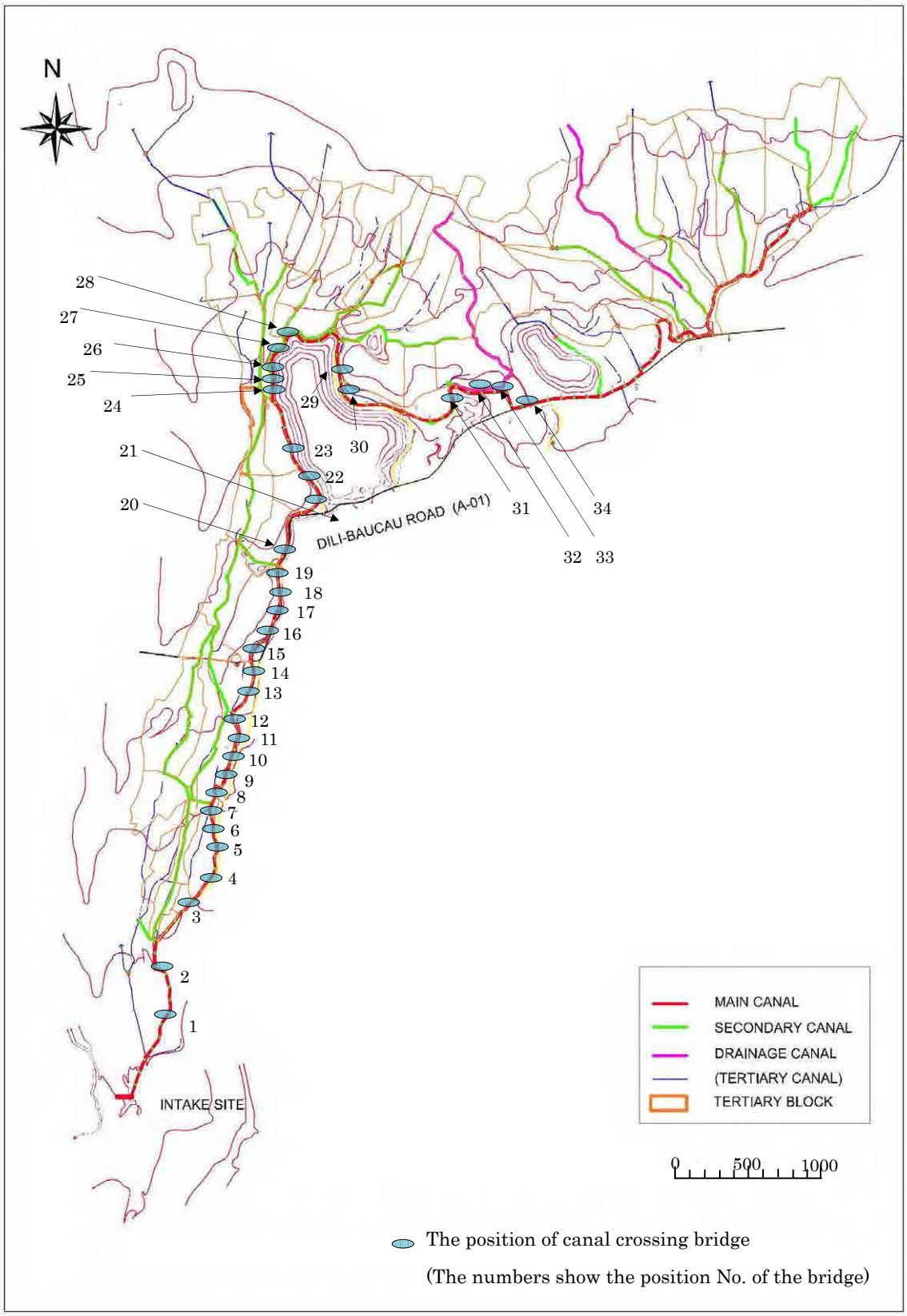


Figure 2-33 Location Map of the Drainage Work

2-2-2-5 Drainage System

1) Present Conditions

Figure 2-34 shows the drainage alignment. The present drainage situation can be summarized as follows:

(a) The upstream of the drainage canal No.1 forms natural drainage canal with widths of 2 to 3m and depth of about 1m. The downstream, however, does not form the clear configuration and flows down over several paddy plots. In this area, the rainfed irrigation is practiced using such drainage water for the irrigation. According to the interview of the farmers, flood damages have occurred in the rainy season of 2010 in 10ha of the downstream area.

(b) The upstream of the drainage canal No.2 forms natural drainage canal with a width of 10m and a depth of 1m. The most downstream basin forms swampy area because of the gentle topography which is apt to receive sediment materials. The flood damages have occurred in the rainy season of 2010 in 4ha of the downstream area.

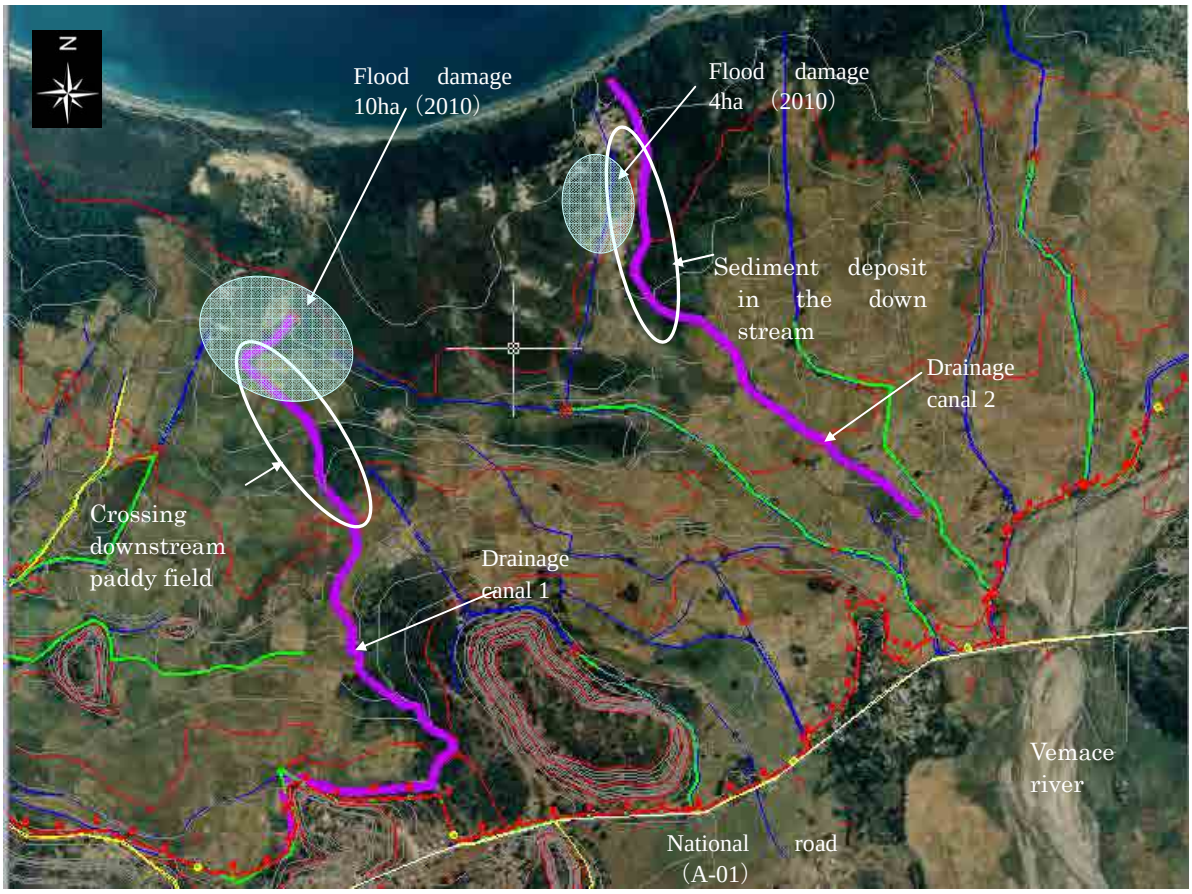


Figure 2-34 Alignment of the Proposed Drainage Canal

Downstream of Drainage Canal 1
The beneficiary area consists of the paddy field. The drainage water can be allowed to flow a wide area of the paddy field in order to avoid the drainage water to concentrate the limited area repeatedly. The reduction of the agricultural land can also be avoided.

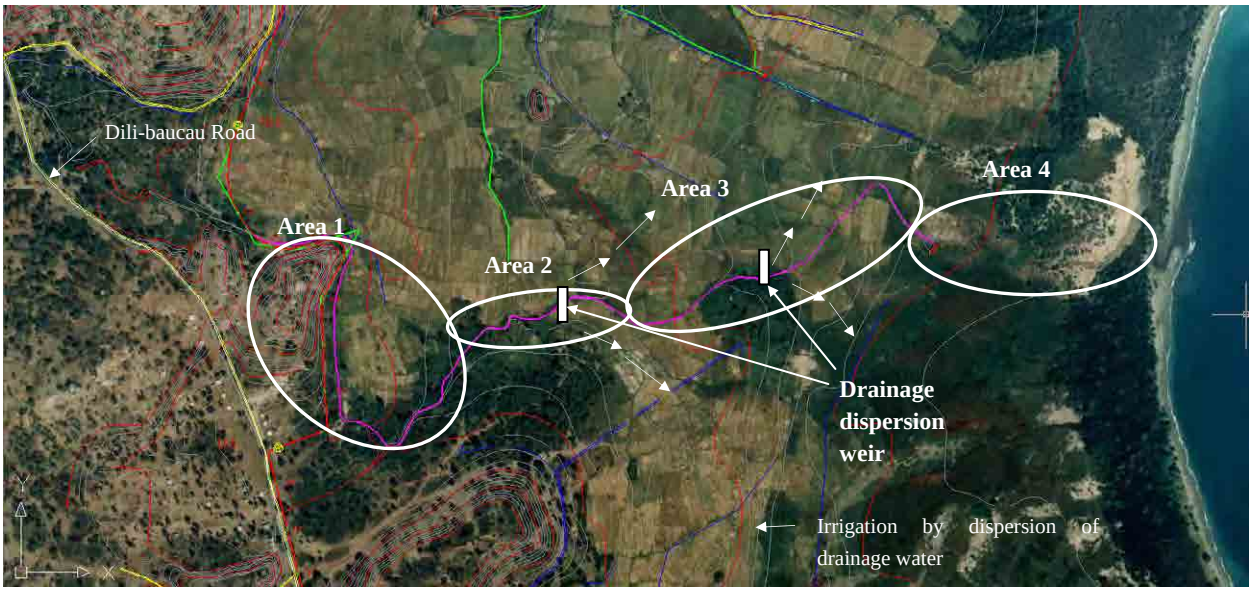
Downstream of Drainage Canal 2
The downstream of the drainage canal does not form the clear configuration of the drainage canal because of the sedimentation of soil and sand. The periodical removal of the soil and sand is required even after the dredging by the present project.

2) Drainage Plan

A drainage improvement plan is discussed hereunder for the drainage canal 1 & 2 with a total length of 4.6km.

Drainage Canal 1

- The inundation damage of the downstream of Area 3 is illustrated in Figure 2-35. This inundation with a depth of 0.5m occurs because of the sediment deposit at the upstream end of Area 4. This condition can be improved by the excavation of a drainage canal in the downstream of Area 3 where the area suffered from inundation damage.
- Area 3 consists of paddy field, and therefore, provision of the drainage canal means loss of the paddy fields. In order not to lose the paddy field, it is panned that no new drainage canal is constructed in this Project, but the drainage water shall be allowed to flow in the several field blocks, instead.
- The existing drainage canal is used as the drainage cum irrigation canal. In Figure 2-35, there are 2 locations where lateral canals start from each side of the drainage canal. It is planned to construct 2 small weirs to irrigate the area in the vicinity as well as to disperse the excess drainage water in order to avoid concentration of flood damage in one place.



Note) Figure 2-36 and 2-37 shows cross sections of the drainage canals for Area 1, 2 and 3.

Figure 2-35　Drainage Area（Drainage Canal 1）

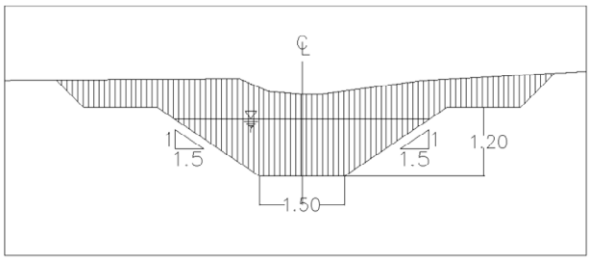


Figure 2-36　Existing Drainage Canal in the Upstream

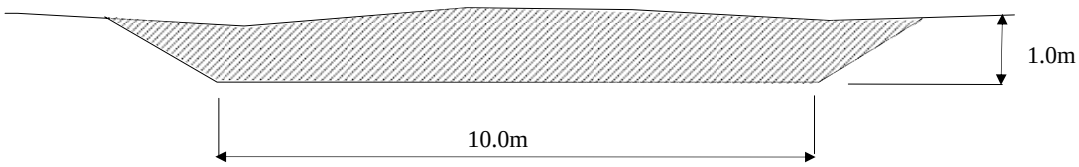


Figure 2-37　Downstream of Drainage and Swampy Area

The unit area drainage discharge was estimated as 3.1 m^3/sec/km^2 based on the rational equation with a time of flood concentration of 0.5 hrs, 2-year probable rainfall intensity of 45.2mm/hr, and a run off ratio of 0.25.

Drainage Canal 2

- Since the upstream of the drainage canal 2 has an approximate section with a width of 10m and a depth of about 1.0m, this drainage canal is presumed as one of old river course of Vemasse River.　Although this depression has formed a 10m wide drainage canal from the

paddy field at present, the sedimentation is in progress in Area 2 (Figure 2-38) and the depression with a depth of as shallow as only 0.3m. Thus, the drainage canal improvement with a width of 10m and a depth of 1.0m is designed as shown in Figure 2-39.

- In Area 3, the sedimentation is also in progress in the depression with a width of as wide as 50m. This is because of drainage hazard by sand dune with a height of about 2m developed in parallel with the sea shore. Therefore, the present drainage condition is planned to be improved by 1) same drainage canal excavation with a width of 10m and a depth of 1.0m as the drainage canal 1, and 2) an outlet of the drainage canal is to be excavated at the sea shore (Since the sedimentation will be continuously in progress in future, periodical removal of sedimentation in the new drainage system shall be required).

- The existing drainage canal is used as the drainage cum irrigation canal. As shown in Figure 2-38, there are at least 2 locations where the existing lateral canals start from each side of the drainage canal. It is planned to construct at least 2 small weirs to irrigate the paddy fields in the vicinity

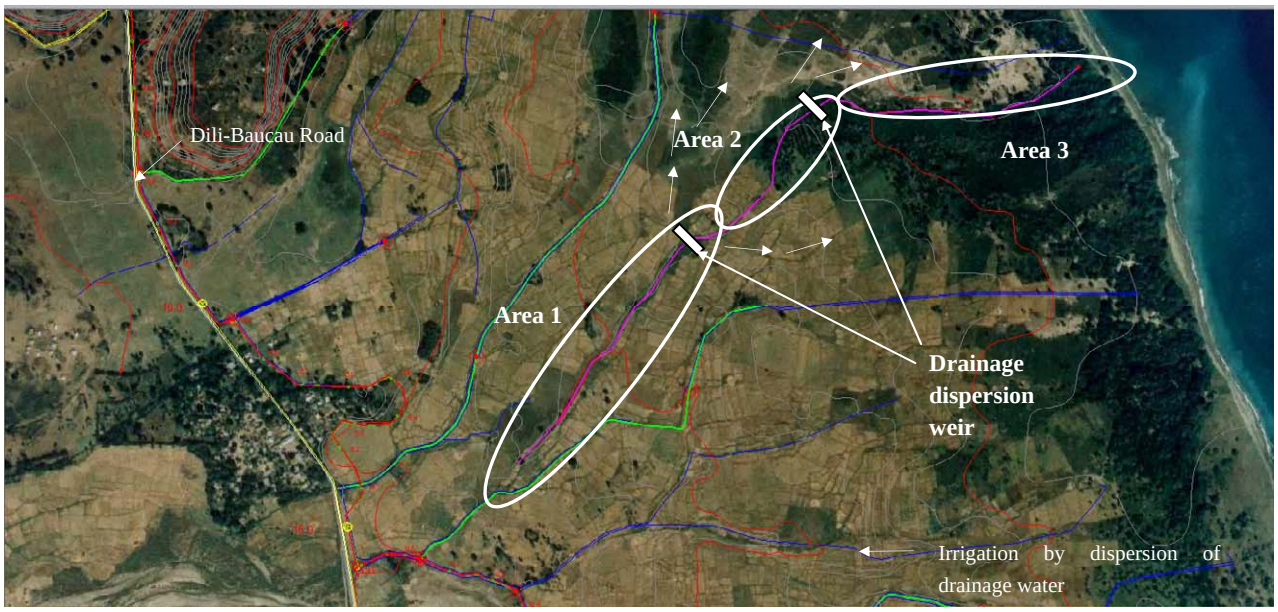


Figure 2-38 Drainage Area (Drainage Canal 2)

The cross section of the drainage canal is planned as follows:

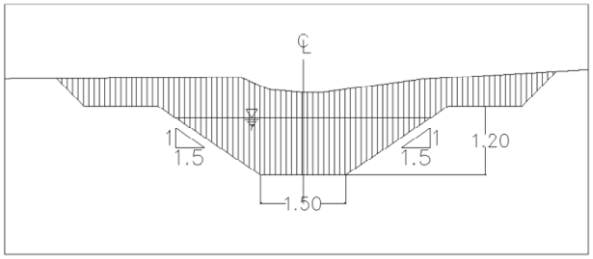


Figure 2-39 Existing Drainage Canal in the Upstream

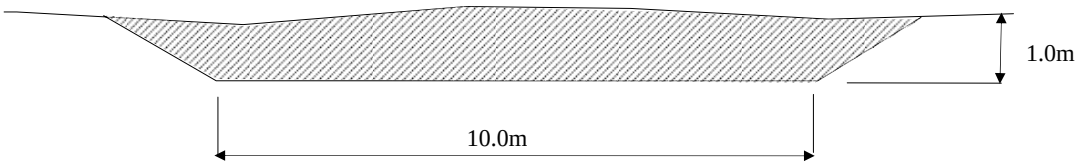


Figure 2-40 Downstream of Drainage and Swampy Area

2-2-2-6 River Revetment Work

(1) Examination on the Revetment Work of Upstream Intake Work

The necessity of revetment work was considered based on the back water calculation at the time of flooding by the proposed weir. Figure 2-41 shows the location map of revetment work, while the relationship between the revetment work and flood back water level of flood is shown in Figure 2-41.

The station No. from BP (0+000) to EP (0+460) is located in the flow channel where the riverbank level is low and overtopping is concerned. Therefore, the examination was conducted to check whether it will cause flooding after the installation of the proposed weir. However, as shown in Figure 2-42, it will not cause flooding after the proposed weir installation even when the flood discharge is 600m^3/s and 800m^3/s. Moreover, the flood level of the upstream and downstream side of the above stations is high because there are hills. Thus, the revetment work will not be necessary in the left bank of the upstream side.

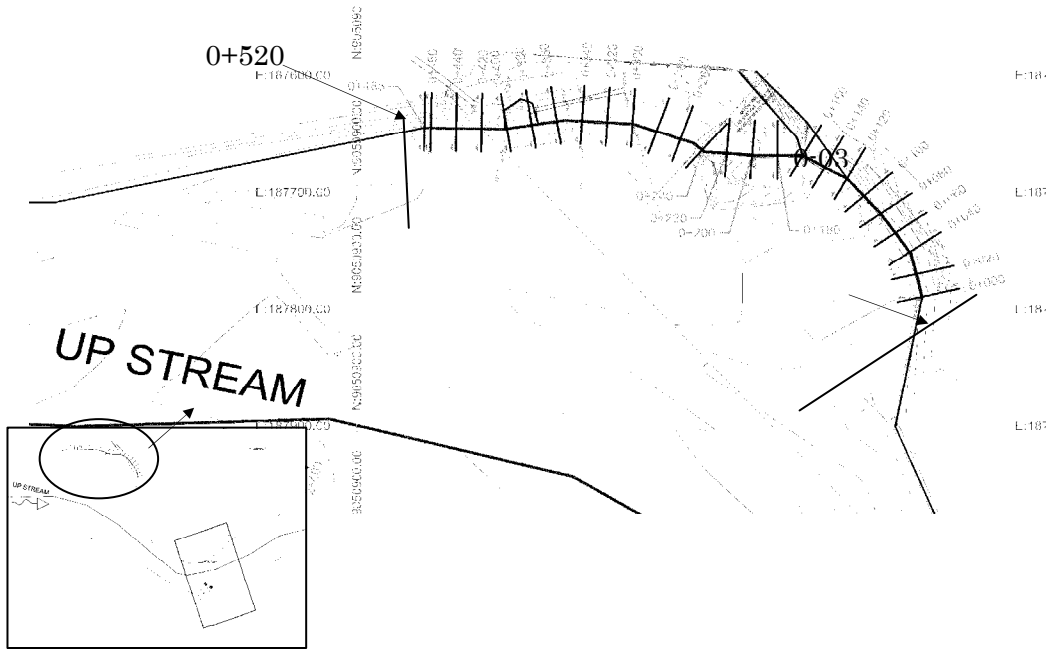


Figure 2-41 Location Map of Revetment Work

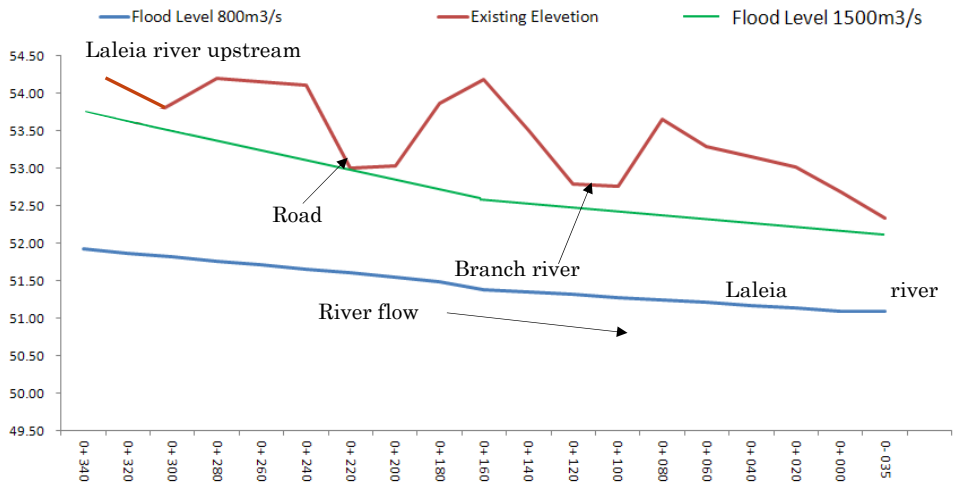


Figure 2-42 Examination of Necessity of Revetment Work

The flow direction of Vemasse River bends largely to right-hand side in the downstream area of Vemasse River bridge. Thus, erosion of the left bank of riverside is in progress by the water-Collision at the time of flooding. At present, the state of its erosion progress is confirmed by the fact that some dikes of paddy fields are broken by the flooding. As shown in Figure 2-43, the revetment work of the riverbank will be constructed in the reach where the main canal is planned to be constructed in contiguity with riverside in order to control the bank erosion and to decrease the damages against irrigation canal.

The crown height of the revetment work will be 1.5m higher than the original ground in average to make its height higher than the flood level of Vemasse River. Figure 2-44 shows the relationship between the flood level of Vemasse River and the crown height of revetment work.

The standard section of revetment work is shown in Figure 2-45. The stone gabion made of 4.0 mm iron wire which will be made by manpower at the field will be used for the revetment work, although in general, the stone gabion made of 2.0mm iron wire is used for this case. The durability of stone gabion is assumed around 10 years (This type of stone gabion is normally used for the revetment work in Indonesia).

The target construction span is 600 m including the protection of intake work of traditional irrigation facilities. At present, the closest distance between the proposed main canal and present riverbank is 30 m.

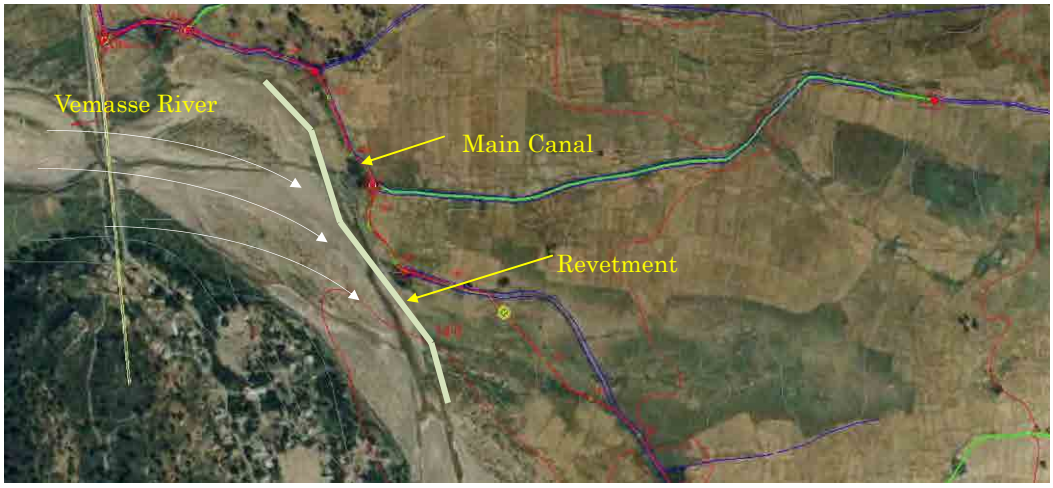


Figure 2-43 Construction Section of the Revetment Work

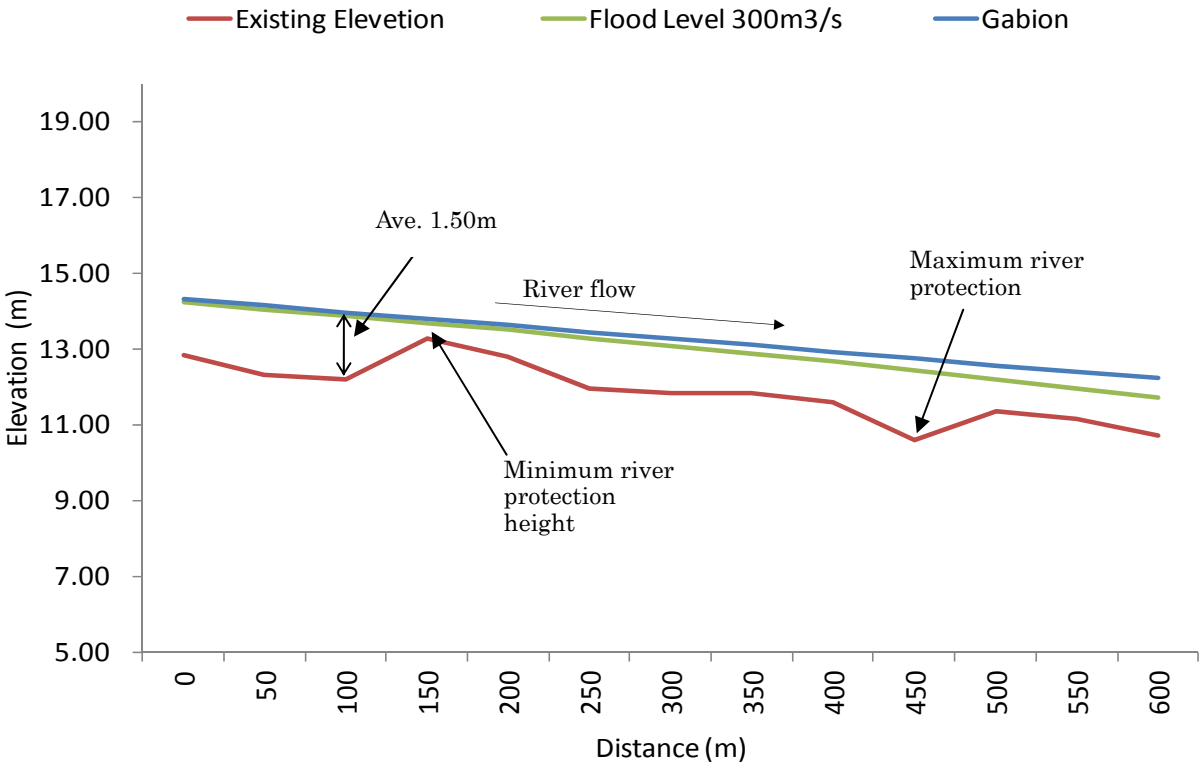


Figure 2-44 Relationship between Flood Level of Vemasse River and the Height of Revetment Work

The depth of embedment of the revetment work will be 1.5 m approximately. Around 30cm of round stones in river-bed will be used for its filling. The iron wire with φ4mm will be knitted by manpower at the field to make the stone netting. This will protect the damages of the entire revetment work.

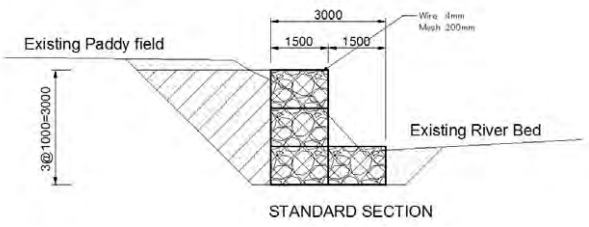


Figure 2-45 Standard Section of Revetment Work

2-2-2-7 Building Works

1) Meeting Facility for WUA

The meeting facility for WUA has a floor area of 60m^2 for the meeting of 50 members. Besides, there is a floor space of 27m^2 for office use.

Floor Area

Floor Area	Meeting facility for WUA
1. Office use	27m^2（6m^2/1 person×4person=24m^2、corridor=3m^2）
2. Meeting room for WUA	60m^2（50persons×1.2m^2=60m^2）
Total	87m^2
3. Toilet	17.5m^2（3.5m×5m=17.5m^2）for water closet with a septic tank shall be provided separately from the office, in consideration of sanitation conditions.

Facilities (plant & equipment)

	Meeting facility for WUA
1. Electricity （Electric distribution from existing grid）	Electric source for room lights (florescence)、personal computer, printer, etc.
2. Water supply system	Supply from water tank（1m^3）
3. Water source	Installation of the existing well. A pump is planned to be procured by the Project.
4. Lightning protection	System including lightning rod

Desks, chairs, etc.

	Meeting facility for WUA
1. Office	Wooden desks: 4sets（about 900mm×1,200mm） Wooden chairs: 4sets
2. Meeting room	50 plastic chairs：50chairs（Possible for easy piling）

2) Gate Control House and Warehouse for Equipment

A gate control house with an area of 60m^2（5m×6m=30m^2 for gate control house） + (5m×6m=30m^2 for warehouse) is planned to be constructed in the area of Intake facility. The gate control house is installed with a simple bedroom considering gate control for night time shift. The purpose of provision of the warehouse is to store the stop logs and spare parts such as sealing materials, bolts, oil for maintenance of the gates, etc.

a) Gate control house

Floor area

Floor area	Gate control house
1. Office	17m^2（3.0m×5.0m=15.0m^2+2.0m×1.0m=17.0m^2）
2. Bed room	9m^2（3.0m×3.0m=9.0m^2）
3. Toilet and shower room	4m^2（2.0m×2.0m=4.0m^2）for toilet seat, washbasin, septic tank
Total	30m^2

Facilities (plant & equipment)

	Gate control house
1. Electricity（Generator）	Electric source for room lights (florescence)、personal computer, printer, etc.
2. Water supply system	Supply from water tank（1m^3）
3. Water source	Construction of ground water well with a depth of 3～4m with pump.
4. Lightning protection	System includes lightning rod

Desk, chair, etc.

	Gate control house
1. Office	Wooden desk ：1set（about 900mm×1,200mm） Wooden chair ：1chair
2. Bed room	Wooden bed ：1set
3. Toilet/shower room	Toilet seat, wash basin, septic tank : 4m^2（2.0m×2.0m=4.0m^2）

b) Warehouse for Equipment

Floor area

Floor area	Warehouse	
1. Stop log for gates	12.0m^2	
2. Oil for maintenance of gate	3.0m^2	
3. Spare parts and material	3.0m^2	
4. Corridor	12.0m^2	
Total	30.0m^2	