Minutes of the Maliana 1 Irrigation System Workshop for the Project Explanation

January14, 2006
Location : District Administration building

9.30am (Alfredo Soares, MAFF Maliana District Irrigation Officer) gives thanks to Government of Japan, Government of Timor Leste, District Administrator, M.A.F.F., Irrigation Division, and ALL farmers.
Introduces the participants of the front table
Mr. Sakai, Pedro, Mr. Tsumura, Vicente, Sub District Administrator
Then Introduces participants; the Chief of villages, Marino's and WUA leaders
9.39 Opening by Sub District Administrator Domingos Martins
Welcomes All, Explains goals of doing a Basic Design and Plan of Implementation, and explains there will be responsibilities of the water users. = INPUTS. This will prevent problems during implementation.
WHO's project is this → YOURS (community) → :. Need to Manage YOURSELF. Workshop here will describe HOW, but opens the project to ideas and questions from YOU.
9.44 OPEN
9.45 Background by Vicente (Chief of Div. Irrigation)
Gives respects to ALL

- Notes that this project is very important for the development of Maliana, important to respect the opportunity that is being given. Support is provided for the project from JICA and Sanyu Consultants in designing the irrigation system. Project hasn't started yet but the process is in place.
- During Indonesian occupation, the farmers of Maliana realized the potential of the Maliana flood plain. Irrigation land is a valuable resource that must be given care.

Explains you are the beneficiaries of a <u>new</u>, big project → so that development stages of the past such as buildings, and fruit trees need to be removed for this project implementation.
Started understanding the potential of irrigation in Portuguese time, Maliana expanded substantially in Indonesian time, when the intake gates were built, this allowed the development of Primary canals. This project will aim to rehabilitate these intake and canals.
Secondary canals were developed in Indonesian time, this project will rehabilitate these.

- JICA aim to "support' this irrigation project, not just by providing a short term INPUT of money, providing paid employment, but this is about long term productivity of Maliana.
- The need to construct a meeting house as a goal of this project is because there will require many decision making processes and problem solving events. The project will require the contribution of some land for this meeting house and this will need to be clarified during this meeting.
- We will ALL benefit a lot from this project so we need to understand that there will be contribution & sacrifices. With this contribution confirmed today the project could then go ahead to the next stage.
- MAFF Maliana Irrigation currently only has 1 staff, Alfredo and there is a proposed 2nd staff from Liquisa, who are responsible for such a large resource → so how are we going to maintain such a large resource? → In Indonesian time, we maintained the system, so can we maintain it now, I believe so, there will be many problems that we will need to resolve.

- If we increase PRODUCTION and increase FOOD Availability → then WHO benefits → those who benefit should maintain the resource → this is YOU, do you want this responsibility, if so you will need to form an association, such as the associations formed in Indonesian times called PPPA or what we will call in this project, WUA (Water Users Association).

Why do we need a WUA? Because there are many beneficiaries → if the water flows ALL will benefit but also ALL need to contribute → so we need 'representatives of each WUA and a board to manage these. (President, Vice President, Treasurer, Secretary). The functioning of the irrigation is important and sustainability will rely on the system being maintained constantly.

- Problem Solving process

Farmer → uses WUA first, → then Board → then Irrigation Division / District Administration → MAFF → other GoTL Ministry will have representatives at WUA meetings → but this is your resource, the WUA needs to control.

There is no need to solve problems with arguments and fighting or police → need to sit together with 1 representative of each household and the WUA can resolve, not MAFF or police first, so we need a stable working environment.

Big decisions, particularly about the water sharing amounts, will be made at WUA meetings. 1 person will be responsible for actually opening the gates but the decisions / plan and schedule will be made by all members of the WUA. → so there will need to be COORDINATION between each of the WUA's → we will need to improve our capacity to manage the irrigation system and to coordinate the activities of each WUA. → there will be a need for 'LEADERS' who will need to decide their own 'Job Descriptions and Responsibilities'

10.13 (Alfredo) Asks for confirmation of - land area, Number of people → outlined the importance of clarifying ALL the members of the WUA beneficiaries. (participants were shy). Alfredo reads out ALL group names and asks for a show of hands from the participants who are representing each group attending this meeting. Alfredo confirms that it will be the DIO responsibility to provide a current list of group names, numbers and members.

10.21 (Alfredo) Outlines the workshop here is a process of feedback, flexibility, and participation starts now. No complaints later once the project has started.

- Components of the project

What does rehabilitation mean, difference between construction? Then there is the New area of construction / lengthening the canal.

- Asks about confirmation of the cropping pattern.
- Explains the importance of strengthening the WUA management capacity.
- Outlines the need to identify all the lengths of canal by group, then WHO is responsible for the repair, construction and maintenance.
- This is why it is important for accurately identifying All the People / households / areas of paddy and fields.
- Problem solving / Decision making → there is a need for protocol → system of allocating decision-making responsibilities → 1 household – 1 representative in problem solving.

Preparation of Non-Physical (or soft) component of the project, which will include training and monitoring. Will need to form a Board of WUA, including a President, Vice President, Treasurer, and Secretary. A manual of regulations will be prepared.

- Will need to have an election → so we need candidates for leaders of WUA groups and the Board of representatives → needs to be a democratic process, including photos of the candidates and an election date for choosing the best people.

There will be problems and benefits with a change to the current irrigation system → it will mean a change in cropping pattern.

- Alfredo asks the Question ***Question:*** 'during the Construction phase it will be the dry season – Can you tell us if are you are willing to receive this project and do the necessary work required to complete the construction?' Crowd replies "We will work and receive the project".

Feedback from Chief of Odomau village (Salomau) " NO group or Nobody in the community will complain or make problems"

Alfredo talks about increasing the volume of water intake from 1 $m^{3/s}$ to 1.37$m^{3/s}$. Need to know when is the best time for construction, and when is timing of maintenance procedures, this will allow us for earlier cropping seasons.

Question: (Jose de Jesus, Lahomean) "What happens if there is not enough water to reach the end users of the canal system, particularly if we intend to extend the system to new areas? Why is one system longer than the other "

Q: (Manuel,) "in Portuguese times we, at the end of the canal system, had rice paddies and irrigated cropping, then after the occupation until now, there was no water → now we can only grow rain-fed maize and root crops because the irrigation water does not come down the canals → there is not enough water. So if you want us, at the end of the canals, to contribute to this project what happens if we don't get enough water → what will be our return on investment? Why should we contribute before we get any result? How will we survive in the meantime? There are no roads at the proposed extension of the canals, what to do about this?

Q: (Estavoa Lopez, Namduras) "regarding the New Construction of Ramaskora and Ritabou canals; how can we expand if the irrigation water comes from the same one source as now, how do you know there will be enough water? Also, the 2 areas are not the same size! Will water be shared equally between the 2 canals 50% Ramaskora, 50% Ritabou? Will this mean 1 system gets more per hectare on average? With the new extension there will be even more demand for water → will there be enough? And will there be enough water for irrigation all year round?

Q: (Salomoa Da Cruz, Chief Odomau) Gives thanks to all, "what is the target of the 2 secondary canals now → how will we be dividing the water 'within' the WUA areas? Who decides WHO gets water from the tertiary canals, with the new project will more people or hectares be demanding more water. Who makes the new tertiary canals?

Q: (Martinho de Alamau, Chief Lahomean) there is a lot of water that can be used from the river, we don't use 100% of what goes into the canal already, so if we propose that the intake increases to 1.37$m^{3/s}$ can we still guarantee that the water will reach all the identified beneficiaries. Also, there needs to be a plan to use different amounts of water in different seasons because we don't just grow rice all year round but other crops with different water requirements. The contribution from the community farmers needs to take into account not all farmers use the same amount of water because they grow different crops at different times of the year.

The current cropping pattern in his area is December planting rice – March harvest, April plant another different crop, and August can grow another type of crop. (In line with the Cropping pattern outlined in the workshop notes, however rice has a much more 'fixed cropping pattern whereas crops and vegetables are more flexible). At present, the cropping pattern is dependant on rainfall, however with the intake and irrigation system operating, more flexibility and possibly earlier cropping will be possible.

Response: (Mr. Tsumura) the rehabilitation and construction of new intake, sediment basin and rising of the weir height will increase the flow amount of water into the system. Importantly it will be the maintenance and cleaning of the system that will decide if all beneficiaries receive the water allocation planned. The design will be engineered to meet all targeted beneficiaries water allocation. (Alfredo) it will be the responsibility of the WUA to make decisions and plans on how the water will be allocated so that all proposed beneficiaries receive what is proposed in this project. Decisions need to be based on numbers of farmers and the area they are irrigating. This is why it is important to confirm this data at this stage of the project. Training in this decision making will be provided in the Soft Component of the project. There will need to be strict regulations on how the secondary canals are used to distribute the water so that all requirements are met. These regulations will be compiled into a manual and decided upon by the WUA, Board and MAFF.

11.43am (Vicente Guterres, MAFF Irrigation Division) Vicente outlines the obligations of MAFF /IWMD's from the workshop notes. Importantly, the list of beneficiaries and areas of irrigation are currently being clarified and Alfredo will provide the information to Mr. Tsumura.

Vicente emphasized that there needs to be a process for problem solving and agreed a system such as that below needs to be documented:

Problem → Farmer → presents problem to WUA in a group meeting
→ Group resolve the problem, if not....................
→ Group leader resolves the problem, if not............
→ Group leader takes the problem to the Board President, Vice President, they resolve problem, if not....
→ Board takes the problem to District Irrigation Officer And D.Administrator, resolve problem, if not...
→ National Irrigation Division MAFF, resolve problem, if not..
→ Ministry, MAFF, Internal Affairs

Vicente says arguing and fighting and the need for police will not be required in this process.

It is important that the Function of the WUA is established immediately, and then the processes and regulations need to be followed. MAFF will assist in establishing the WUA groups operating procedures and monitor the WUA activities. The WUA needs its own structure to be maintained with their own regulations on how the water will be allocated within the individual WUA group.

MAFF obligations will be to inform the WUA about the timing of Operations and Maintenance of the canals. You the farmers use the water, you will benefit, so...It is the responsibility of the WUA to collect the water fees for O/M. Vicente mentions some of the problems of the Manatutu Irrigation System and says the WUA needs to be strong and follow the regulations that the WUA decides.

Vicente outlines the costs of O/M and how MAFF will subsidize fees for first 5 years by 70%, then next 5 years for 30%, after this the WUA will be fully responsible for costs of O/M. GoTL needs participation and contribution if the nation is to develop, so MAFF will support the WUA groups but must realize that in the future your responsibility will increase. This is your project. The MAFF will be focusing on many areas of agriculture, not just irrigation, so those fortunate enough to be able to irrigate should take most responsibility.

12.02 Vicente outlines the responsibilities of the beneficiaries according to the workshop notes. States that water is free, but the facilities to distribute water are not. The tertiary canals go directly to YOUR padi, so YOU will need to build and control them. The proposal does not include tertiary canals. You will need to contribute the land for canals and the meeting room facilities. Your participation is in building Your canals.

Outlines that After construction the WUA will be making many decisions, like payments to Board, funds for O/M (how much, how to pay) and cleaning of silt and grass from the canals. Outlines election process to elect WUA leaders, this needs to happen in March. Process will be democratic, including photos of candidates and the reasons for them to be leader. All beneficiaries need to vote.

Q: (Alberto Fernandes, Raifun) "The farmers are clear on their obligations and will need further socialization as the process of the project implementation begins. Can you clarify when the project will start? Will Government help in the election process?
Alberto also says please do not compare other places and projects to Maliana, as they believe that can guarantee success of this project, the community is ready to make contribution and participation. Maliana conditions are well understood by the farmers, this will lead to success and there is no need to bring other people from other areas to do the work in this project.
R: (Mr. Sakai☺) says in his experience that it will take at least a year before the Government of Japan and Government of Timor L. sign any agreements and then a detailed survey, architectural design and concise implementation plan will be developed. This would suggest the project will not start construction phase for 2 years. However, the first step is forming the WUA groups and strengthening the capacity of these to manage the irrigation. If this process happens rapidly and smoothly, with positive feedback from the WUA farmer groups, then maybe the process can be a little faster. Government of Japan will need some evidence that the WUA are formed and operating first.
(Mr. Sakai) he said that he is not the right person who will make the decision on this project. Because he is just an advisor for TL government, so he is on TL side. He is not sure about when the project starts to implement. The process is the government of Japan will make internal agreement first, which will take time about 1-2 years, and then they make agreement with government of Timor Leste. However, the farmers of Maliana I have show that they are committed to contribute to the sustainability of the irrigation system that will be rehabilitated and constructed by establishing an association that will manage the irrigation system.

Q: (Mr. Tsumura) There are estimated O/M costs provided in the workshop notes, do you fully understand that MAFF will only be subsidizing 70% for first 5 years, 30% for next 5 years then no more subsidy. This means that that you will need to collect a water fee, so <u>how</u> will you do this in the WUA and <u>how much</u> are you willing to pay? The project is planned to begin the physical construction phase of the project at the beginning of 2008.
R: (All) We understand the costs involved in O/M!
We will be very happy to contribute to the project and will be grateful for the increase in food production, however, if increased yields and quality are improved and there is still not a good market (price, amounts demanded, imported rice, storage infrastructure), then how will the farmers be able to pay any fees.
Q: Currently, the price for unmilled padi is 12c/kg, which apparently doesn't support the cost of production → this problem needs to be solved. Could pay \$1 - \$2 but if there is no prices or demand for our product then how can we pay. We have the positive interest in the project, we want to contribute, we also want to increase our yields but WHO will buy our product, the government needs to buy and give a good price (requesting \$1/kg). Don't want to talk politics but the Indonesian system that guaranteed that our product is purchased and at a fixed good price made farming possible. Request the Government also assist with improving the quality of our milled rice so that we can compete with the imported rice.
12.52 R: (Vicente) Answers the question with another question 'if the irrigation is operating and some areas need repair and maintenance, WHO will pay for this if the users do not pay". Provides some encouragement and outlines there will much more benefits for the whole community from this

project, not just for rice growers. Your contribution will begin with the formation of the WUA. We need direction, to show the 2 Governments that we are ready to start the project. Then MAFF and WUA can work together to make the decision quicker.
About the price of rice, MAFF cannot control the price of imports and this is what sets the price of the local rice.
Q: (Mr. Tsumura) Repeats his initial direct question "How much can you pay for WUA fee?" asks that we discuss this after lunch.
1.00pm (Alfredo) Outlines the importance of forming the WUA, using the democratic election process to find group leaders, which needs to start now so we can clarify Group name, leader, beneficiaries/ members and areas.

2.00 (Chiefs talking) ***Q:*** How and when are we going to have an election, based around what groups, what are the criteria to be a group (area, like 30 hectares, or by number of houses/people, water requirement????
Some confusion around this upcoming election.
A W.U.A is What?
R: WUA is:

Has a name
Represents an area / and a group of people farming that area.
Represents a group of water users.
Represents the primary group of people to solve problems

Aim is to determine how much water is required for this group ($m^{3/s}$)

Decided by area and cropping pattern (crop water requirements)
The decisions then allow for a strategy / regulation to be formulated for water allocation → so all WUA will submit a plan for their water use requirements for each WUA → then all WUA leaders and Board make decisions and a plan for the water use for the whole system → then a timetable for m^3 volumes and times for water allocation to each WUA can be formulated.

Q: (Mr. Tsumura) Repeats his initial direct question "How much can you pay for WUA fee?"

Name	$ / Ha / year
Chefe Alberto Fernandes	$1 (even more based on election promises)
Chefe Martinho	$0.50
Chefe Salomao da Cruz	$5.00 (because he knows in the dry season if he has irrigation he will be able to grow cash crops and increase his income).
Chefe Estevao Lopez	$0 (Because he hasn't seen any water yet, not pay until he gets a financial return)
Martinho de Alamau, Chief Lahomean	Can even pay $10, but everyone's cropping reason is different (food or cash) and income is not the same. Suggest fee increases as production and profits increase (like 5% of profit)

Mr. Vicente explained to beneficiaries one example of another WUA namely; Caraulun irrigation scheme, that MAFF is planning to collect 16US$/ha per year for water use.
R: The result of the village Chiefs' discussions is that they expressed US$**5**/ha for initial stage until profits from farming increase.
R: (Alfredo) Insists that if you want to increase $ from your land, and get irrigation, then you will need to contribute to the maintenance.
R: (Subdistrict Admin Sr Domingos) "He is confident that the design will provide ALL targeted beneficiaries with water, because of the potential volume of water that can be taken from the river. There will be a large workload managing the O/M of the system. Are the farmers ready to do the maintenance and pay for the materials?
It is important that we receive the complete and accurate number of beneficiaries / WUA members, and we need to know that ALL in the WUA are interested in the project. If all members are recorded then the water user's fee can be distributed among all so that each is a small fee. Need accurate numbers, data clarity.
The basic design is ready, the plan is ready → are you farmers??
Q: Some farmers may get to plant crops X 2 per year, whilst others only grow one, so if we all pay the same fee this does not seem fair → suggest that the fee be based on the number and area of crops grown e.g.; $5 for 2 crops, $2.50 for 1 crop. What about people who are in the irrigation area but do not use irrigation, do they have to pay for something they do not use?
If a section of the canals is broken and needs repair we need to discuss WHO will repair and WHO pays.
R: (Vicente) "we understand that people have limited cash. We need to make decisions now, who is responsible for O/M. The proposal is in design phase and is not yet fixed; YOU must make decisions, go to workshops and learn the process of participation.
The capacity of the river has been determined and now we need accurate data about numbers of people in the WUA and the area of the beneficiaries. Then we can calculate the correct maintenance costs and the water user's fee. Also we can start to plan the irrigation water schedule for allocation.
Vicente respects the people of Maliana and is confident that they <u>will</u> come up with a positive response to the responsibilities presented to the new WUA members. There will be responsibilities to utilize the funds wisely and accountability is important.
Q: (elderly farmer) "I have 2 hectare of land but because of labor and cash constraints can only use 1 hectare, what will be my water use fee.
R: (Vicente) This period of the design process is where the WUA must make decisions on how contributions to O/M are collected. Need to resolve, and now is the time to use the WUA process and the regulations YOU set, to decide payment. You will not need, arguing, MAFF or police.
Q: Understand that the community uses the canal, and understand the need to make contributions, but still there are some people who CAN get access to irrigation but chose not to use irrigation, Do they pay?
R: (Vicente) "whoever uses irrigation water must pay for the water, other small water use members will have to be determined by the WUA and the regulations they make on how much water and its cost."
Q: Some people will have a problem paying money, are there alternative methods of payment.
R: (Alfredo) "You can pay in rice or other goods, the WUA needs to make the decisions on how and the value of these products.

Q: (Mr. Tsumura) "There needs to be a President, Vice president, Secretary and Treasurer appointed and a decision made on if these appointments will be volunteers or will there be some form of payment (in cash, water or food).
R: (Chefe Salomao) These positions will be very hard work, and will need strong decision makers. He believes that the Government should play these roles at the beginning of the project. MAFF, Chefe of village and the WUA leaders need to make decisions on who and how much, particularly utilizing the district and sub-district Government officials.
R: (Alfredo) To make decisions on how to pay and how much these positions (and other expenses), we need to begin with strengthening the capacity of the WUA groups and the leaders. An outline of the training that will be provided to the WUA was discussed from the workshop notes.

(Alfredo) Summary of tasks and responsibilities

WUA formed

Board Members (4) chosen.

Survey of beneficiaries numbers, areas, water needs,

Cropping pattern detailed

Water we have, then we needs a detailed plan on how to manage it. Begin the process of setting regulations.

Determine how we will collect the water user fee and its management.

After construction obligations

Manual of regulations for operations and maintenance – workshop to assist

Outline of the Schedule of Project Implementation

The Base Design study is near completion

Now we need the WUA groups formed and trained

Then a M.O.U. between Governments can be drawn up.

Then within next 2 years implementation can begin.

(Sub district Administrator Domingos) This workshop had simple objectives to determine if members of the WUA are positive about implementing this project and if they understand the responsibilities and contributions. There are over 1000 beneficiaries that need to know about these responsibilities.
This project will utilize all of MAFF divisions, not just the Irrigation Division. The benefits of the project will flow on to all community farmers.
Gives thanks to all participants and hopes to see you all soon. The take home message from this workshop is that the community positively wants this project to go ahead and they are willing to contribute to its success.
3.00pm Workshop closed

List of Participants

No	Name	Organization
1	Yuki Kuraoka	Jica Timor Leste
2	Martinho Bili Mau	Chefe suco Lalonca
3	Jasino Araujo Soares	Com.ESQ. Maliana
4	Antonio Marques	Suco Raifun
5	Arcanjo R. Tilman	Dist. Development Officer Bobonaro
6	Juvenal C Soares	MAFP / Central
7	Manuel S. Barreto	Agriculture
8	Estavao Lopes	Agriculture
9	Natalino Araujo	Agriculture
10	Matheus Mau	Agriculture
11	Alberto A. Fernandes	Chief Village Raifun
12	Ponciano de Fatima	Village Council,
13	Paulo Afonso	Agriculture
14	Filomeno G.M.	Youth Representative/ Radio Community. Maliana
15	Domingos Monis	Chief sub-village
16	Domingos Lopes	Agriculture
17	Tome Vicenti	Representative Ritabou
18	Cristavao F.	Chief Sub-village Saunleu
19	Manuel Lopes	Agriculture
20	Jose de Jesus	Agriculture
21	Antonio Santa Cruz	Village Chief
22	Faustino R. Bere	Focal Point Meio Ambiente
23	Maria do Carmo V.Moreiro	Cabinet S.F.R. IV
24	Alipio Moniz	Community Development Officer Sub-district Maliana
25	Salomao Da Cruz	Chief Village Odomau
26	Juvinal Salvador	Agriculture
27	Joaquim M.	Aldeia Maganotu
28	Antonio	Aldeia Ritabou
29	Manuel Henrique	Agriculture
30	Luis de Oliveira	Agriculture
31	Duarte Lelo	ASC. Bobonaro
32	Rui Mamuel Lasi	Irrigation Division MAFF
33	Celestino Henrique	Irrigation Division MAFF
34	Fernando Dos Santos	Ritabou / Samelau
35	Domingos Martins	Administrator Sub-district Maliana
36	Vicente H. Guterres	Chief Irrigation National Office
37	Kazumitsu Tsumura	Sanyu Consultants
38	Pedro Laurentino da Silva	Independent Consultant/ Translator
39	Shinobu SAKAI	Advisor to MAFF
40	Robin Jong	ARO Unit JICA
41	Alcino Mauleto	Group leader
42	Chris Walsh	World Vision Food Security Officer
43	Julio Goncalves	World Vision
44	Moizes Pereira	Group leader Manama
45	Juvenal Salvador	Odamau
46	Alfredo Soares	Maliana
47	Joao justinho	Holsa
48	Dinis A	Holsa
49	Domingos M	Holsa

Dimension of Existing Main Canal

Section name	Section (survey point)		Section length	Bottom width	Crest width	Retention wall	Bank gradient	Section gradient		Section shape
	starting point	end point	L (m)	B (m)	W (m)	Heght H (m)	1 : N	I	I	
A	STA.0+030	STA.0+070	40	2.00	2.20	1.00	0.10	0.004000	1/250	trapezoidal open canal
B	STA.0+070	STA.0+340	270	2.40	4.40	1.00	1.00	0.003333	1/300	trapezoidal open canal
C	STA.0+340	STA.0+660	320	2.10	3.80	1.00	0.85	0.000556	1/1,800	trapezoidal open canal
D	STA.0+660	STA.0+690	30	1.20	1.30	1.10	0.05	0.002857	1/350	Flume canal
E	STA.0+690	STA.0+740	50	1.20	1.30	1.10	0.05	0.002857	1/350	Culvert Canal
F	STA.0+740	STA.0+815	75	1.60	1.60	1.80	0.00	0.005000	1/200	Aqueduct
G	STA.0+815	STA.1+175	360	1.10	2.90	1.20	0.75	0.004000	1/250	trapezoidal open canal
H	STA.1+175	STA.1+527	352	1.50	3.30	1.00	0.90	0.002222	1/450	trapezoidal open canal
Total or mean	STA.0+030	STA.1+527	1,497	1.64	2.60	1.15	0.46	0.003103	1/320	

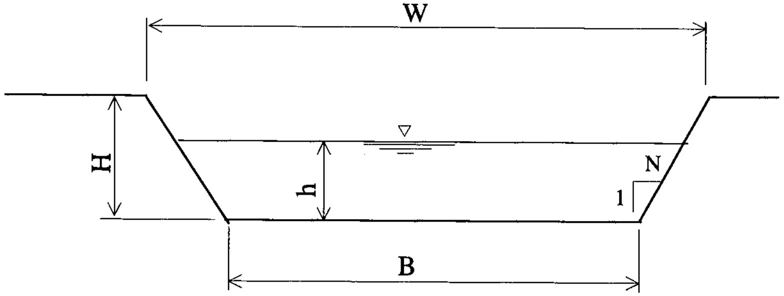
Dimension of Existing Ramaskora Secondary Canal

Section name	Section (survey point)		Section length	Bottom width	Crest width	Retention wall	Bank gradient	Section gradient		Section shape
	starting point	end point	L (m)	B (m)	W (m)	Heght H (m)	1 : N	I	I	
A	STA.0+000	STA.0+355	355	1.80	3.50	0.80	1.06	0.002500	1/400	trapezoidal open canal
B	STA.0+355	STA.0+710	355	1.40	2.70	0.70	0.93	0.003333	1/300	trapezoidal open canal
C	STA.0+710	STA.1+040	330	0.80	0.90	0.85	0.06	0.010000	1/100	Flume canal
D	STA.1+040	STA.1+470	430	1.20	2.50	0.65	1.00	0.005000	1/200	trapezoidal open canal
E	STA.1+470	STA.1+573	103	1.00	2.40	0.55	1.27	0.005556	1/180	trapezoidal open canal
Total or mean	STA.0+000	STA.1+573	1,573	1.24	2.40	0.71	0.86	0.005278	1/190	

Dimension of Existing Ritabau Secondary Canal

Section name	Section (survey point)		Section length	Bottom width	Crest width	Retention wall	Bank gradient	Section gradient		Section shape
	starting point	end point	L (m)	B (m)	W (m)	Heght H (m)	1 : N	I	I	
A	STA.0+000	STA.0+210	210	1.10	2.40	0.60	1.08	0.001429	1/700	trapezoidal open canal
B	STA.0+210	STA.0+760	550	1.00	2.10	0.60	0.92	0.002000	1/500	trapezoidal open canal
C	STA.0+760	STA.1+025	265	1.10	2.20	0.60	0.92	0.005000	1/200	trapezoidal open canal
D	STA.1+025	STA.1+400	375	1.20	2.40	0.60	1.00	0.005000	1/200	trapezoidal open canal
E	STA.1+400	STA.2+000	600	0.80	2.00	0.55	1.09	0.006250	1/160	trapezoidal open canal
F	STA.2+000	STA.2+600	600	0.80	1.90	0.55	1.00	0.005000	1/200	trapezoidal open canal
G	STA.2+600	STA.2+890	290	0.80	1.90	0.55	1.00	0.005000	1/200	trapezoidal open canal
Total or mean	STA.0+000	STA.2+890	2,890	0.97	2.13	0.58	1.00	0.004240	1/240	

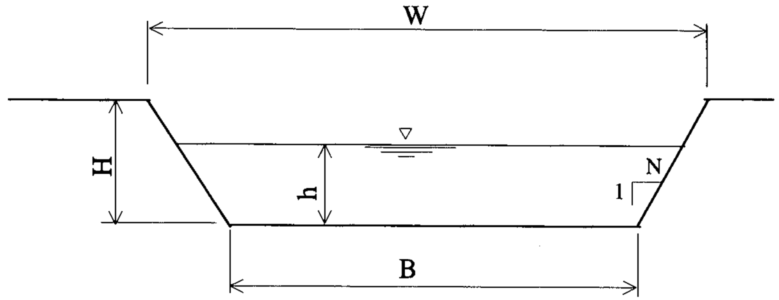
Conveyance Capacity of Existing Main Canal



Item	Sign	Unit	Maliana I Main Canal							
			Section A	Section B	Section C	Section D	Section E	Section F	Section G	Section H
Canal type	—	—	Open Canal			Flume canal	Culvert	Aqueduct	Open Canal	
Cross section	—	—	Trapezoidal				Longutudinal		Trapezoidal	
Section	STA.	m	STA.0+030 ~0+070	STA.0+070 ~0+340	STA.0+340 ~0+660	STA.0+660 ~0+690	STA.0+690 ~0+740	STA.0+740 ~0+815	STA.0+815 ~1+175	STA.1+175 ~1+527
Section Length	L	m	40	270	320	30	50	75	360	352
Bottom width	B	m	2.00	2.40	2.10	1.20	1.20	1.60	1.10	1.50
Crest width	W	m	2.20	4.40	3.80	1.30	1.30	1.60	2.90	3.30
Ret.wall height	H	m	1.00	1.00	1.00	1.10	1.10	1.80	1.20	1.00
Ret.wall slope	N	—	0.10	1.00	0.85	0.05	0.05	0.00	0.75	0.90
Cross sectiongradient	I	—	1/250	1/300	1/1,800	1/350	1/350	1/200	1/250	1/450
			0.004000	0.003333	0.000556	0.002857	0.002857	0.005000	0.004000	0.002222
Roughness coef.	n	—	0.032	0.032	0.032	0.032	0.025	0.015	0.032	0.032
Water depth	h	m	0.70	0.70	0.70	0.80	0.80	0.80	0.90	0.70
Flow section	A	m^2	1.45	2.17	1.89	0.99	0.99	1.28	1.60	1.49
Wetted perimeter	P	m	3.41	4.38	3.94	2.80	2.80	3.20	3.35	3.38
Hydraulic depth	R	m	0.425	0.495	0.479	0.353	0.353	0.400	0.477	0.441
Flow velocity	V	m/s	1.12	1.13	0.45	0.83	1.07	2.56	1.21	0.85
Discharge	Q	m^3/s	1.62	2.45	0.85	0.83	1.06	3.28	1.93	1.27

Manning' Formula : $Q = A \times 1/n \times R^{2/3} \times I^{1/2}$

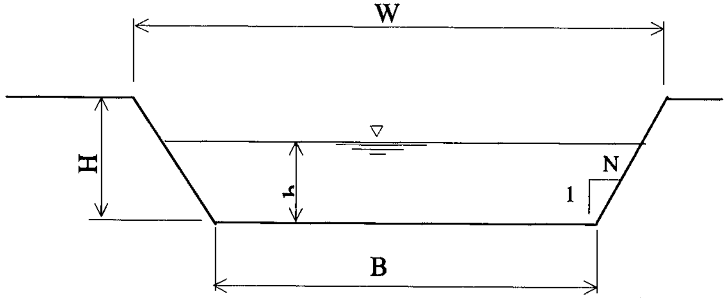
Conveyance Capacity of Existing Ramaskora Secondary Canal



Item	Sign	Unit	Ramaskora Secondary Canal				
			Section A	Section B	Section C	Section D	Section E
Canal type	—	—	Open Canal				
Cross section	—	—	Trapezoidal				
Section	STA.	m	STA.0+000 ～0+355	STA.0+355 ～0+710	STA.0+710 ～1+040	STA.1+040 ～1+470	STA.1+470 ～1+573
Section Length	L	m	355	355	330	430	103
Bottom width	B	m	1.80	1.40	0.80	1.20	1.00
Crest width	W	m	3.50	2.70	0.90	2.50	2.40
Ret.wall height	H	m	0.80	0.70	0.85	0.65	0.55
Ret.wall slope	N	—	1.06	0.93	0.06	1.00	1.27
Cross sectiongradient	I	—	1/400	1/300	1/100	1/200	1/180
			0.002500	0.003333	0.010000	0.005000	0.005556
Roughness coef.	n	—	0.032	0.032	0.032	0.032	0.032
Water depth	h	m	0.55	0.45	0.60	0.40	0.35
Flow section	A	m^2	1.31	0.82	0.50	0.64	0.51
Wetted perimeter	P	m	3.40	2.63	2.00	2.33	2.13
Hydraulic depth	R	m	0.385	0.311	0.250	0.275	0.237
Flow velocity	V	m/s	0.83	0.83	1.24	0.93	0.89
Discharge	Q	m^3/s	1.08	0.68	0.62	0.60	0.45

Manning' Formula : $Q = A \times 1/n \times R^{2/3} \times I^{1/2}$

Conveyance Capacity of Existing Ritabau Secondary Canal



Item	Sign	Unit	Ritabau Secondary Canal						
			Section A	Section B	Section C	Section D	Section E	Section F	Section G
Canal type	—	—	Open Canal						
Cross section	—	—	Trapezoidal						
Section	STA.	m	STA.0+000	STA.0+210	STA.0+760	STA.1+025	STA.1+400	STA.2+000	STA.2+600
			~0+210	~0+760	~1+025	~1+400	~2+000	~2+600	~2+890
Section Length	L	m	210	550	265	375	600	600	290
Bottom width	B	m	1.10	1.00	1.10	1.20	0.80	0.80	0.80
Crest width	W	m	2.40	2.10	2.20	2.40	2.00	1.90	1.90
Ret.wall height	H	m	0.60	0.60	0.60	0.60	0.55	0.55	0.55
Ret.wall slope	N	—	1.08	0.92	0.92	1.00	1.09	1.00	1.00
Cross sectiongradient	I	—	1/700	1/500	1/200	1/200	1/160	1/200	1/200
			0.001429	0.002000	0.005000	0.005000	0.006250	0.005000	0.005000
Roughness coef.	n	—	0.032	0.032	0.032	0.032	0.032	0.032	0.032
Water depth	h	m	0.40	0.40	0.40	0.40	0.35	0.35	0.35
Flow section	A	m^2	0.61	0.55	0.59	0.64	0.41	0.40	0.40
Wetted perimeter	P	m	2.28	2.09	2.19	2.33	1.84	1.79	1.79
Hydraulic depth	R	m	0.269	0.262	0.268	0.275	0.225	0.225	0.225
Flow velocity	V	m/s	0.49	0.57	0.92	0.93	0.91	0.82	0.82
Discharge	Q	m^3/s	0.30	0.31	0.54	0.60	0.38	0.33	0.33

Manning' Formula : $Q = A \times 1/n \times R^{2/3} \times I^{1/2}$

5-6 Record of Proposed Canal Structure

Proposed Main Canal

No.	Name of Structure	No. of Structure	Station	Location	Elements	Remarks
1	Main canal B.P.	–	0 + 030	–	B: 2.1m x H: 1.0m	Trapezoidal canal
2	Side ditch type spillway	–	0 + 050	Right bank	L: 2.5m x ⊿H: 0.3m x 2sets	with stop-log, repairing joint and mortar
3	River protection work	–	0 + 090	Right bank	H: 5.0m x L: 20.0m	new construction: wet masonry work
4	Wooden footbridge (No.1)	–	0 + 150	–	W: 0.5m x L: 4.5m	Overall restoration、
5	Drainage crossing work (No.1)	–	0 + 160	Left bank→ Right bank	corrugated pipe D 1,000mm x 1sets	Partial rehabilitation : outlet wet masonry, H: 3.0m x L: 10.0m
6	Wooden fence(No.1)	–	0 + 165	–	H: 1.0m	Conventional wooden fence, remove
7	Right bank wet masonry work (No.1)	–	0 + 170	Right bank	H: 3.5m x L: 20.0m	New construction: wet masonry work
8	Right bank wet masonry work (No.2)	–	0 + 235	Right bank	H: 3.5m x L: 10.0m	New construction: wet masonry work
9	Small-sized turn out (No.1)	–	0 + 312	Right bank	Hole around D100mm	Rehabilitation : stop-log type
10	Transition	BM-1	0 + 340	–	Partial flume type	Use existing one, removal of broken measuring device
11	Scouring gate	BM-2	0 + 412	Right bank	steel-made slide gate B: 1.5m x H: 1.2m x 2sets	Gate body : Overall rehabilitation, Connective side-wall : partially utilize (repair with mortar) Bottom of scoring sluice : rehabilitation
12	Drainage crossing work (No.2)	–	0 + 425	Left bank→ Right bank	corrugated pipe D 1,000mm x 1sets	Use existing one
13	Concrete footbridge	–	0 + 430	–	W: 0.5m x L: 4.5m	Use existing one
14	Small-sized Turn out (No.2)	–	0 + 430	Right bank	Hole around D100mm	Rehabilitation : stop-log type
15	Wooden fence (No.2)	–	0 + 465	–	H: 0.8m	Small-sized wooden fence, remove
16	Washing basin (No.1)	–	0 + 500	Left bank	L: 1.5m x H: 0.3m x 1step	Overall repairing
17	Wet masonry work	–	0 + 550	Right bank	H: 2.5m x L: 19.0m	New construction: wet masonry work
18	Drainage crossing work (No.3)	–	0 + 575	Left bank→ Right bank	Corrugated pipe D 1,000mm x 2sets	Use existing one, wooden fence remove
19	Small-sized Turn out (No.3)	–	0 + 580	Right bank	Hole around D100mm	rehabilitation : stop-log type
20	Flume canal B.P.	–	0 + 660	–	B: 1.7m x H: 1.3m	Trapezoidal canal, examine section again
21	Covered flume canal B.P.	–	0 + 693	–	B: 1.2m x H: 1.1m	Trapezoidal canal, examine section again
22	Covered flume canal E.P.		0 + 730	–	B: 1.2m x H: 1.1m	Trapezoidal canal, examine section again
23	Aqueduct B.P.	BM-2a	0 + 742	–	B: 1.8m x H: 1.0m	Trapezoidal canal, examine section again
24	Aqueduct E.P.	BM-3	0 + 805	–	B: 1.8m x H: 1.0m	wet masonry work and wooden stepping board rehabilitation
25	Vertical drop work (No.1)	BM-4	0 + 843	–	⊿H: 1.5m x W: 2.0m	50% repairing with mortar
26	Washing basin (No.2)	–	0 + 865	Left bank	L: 2.0m x H: 0.3m x 1step	Overall repairing
27	Transient point of canal section	–	0 + 911	–	W:3.1～1.6m x H: 0.7m x N: 1.0	
28	Corrugated footbridge	–	0 + 915	–	W: 1.0m x L: 2.5m	Use existing one
29	Corrugated footbridge	–	0 + 935	–	W: 1.0m x L: 2.5m	Use existing one
30	Washing basin (No.3)	–	0 + 995	Left bank	L: 1.0m x H: 0.3m x 2steps	Overall repairing
31	Concrete bridge	–	1 + 000	–	W: 2.5m x L: 3.0m	Use existing one
32	Domestic water pipe crossing work	–	1 + 015	–	D30mm x L: 4.m	Use existing one
33	Small-sized Turn out (No.4)	–	1 + 060	Right bank	D300mmpipeturn-out	Rehabilitation : stop-log type
34	Drainage crossing work (No. 4	–	1 + 075	Left bank→ Right bank	corrugated pipe D 1,000mm x 1set	Partial rehabilitation : outlet wet masonry, H: 4.0m x L: 10.0m x 3sites
35	Wooden footbridge (No.2)	–	1 + 100	–	log 2piece	Overall restoration
36	Washing basin (No.4)	–	1 + 125	Left bank	L: 2.0m x H: 0.3m x 2steps	Overall repairing
37	Wooden footbridge (No.3)	–	1 + 130	–	log 2piece	Overall restoration
38	Wooden footbridge (No.4)	–	1 + 140	–	log 2piece	Overall restoration
39	Washing basin (No.5)	–	1 + 145	Left bank	L: 2.0m x H: 0.3m x 1step	Overall repairing
40	Vertical drop work (No.2)	BM-5	1 + 175	–	⊿H: 0.6m x W: 2.0m	Overall rehabilitation
41	Washing basin (No.6)	–	1 + 220	Right bank	L: 2.0m x H: 0.3m x 1step	Overall repairing
42	Washing basin (No.7)	–	1 + 230	Right bank	L: 2.0m x H: 0.3m x 1step	Overall repairing
43	Washing basin (No.8)	–	1 + 238	Right bank	L: 2.0m x H: 0.3m x 2steps	Overall repairing
44	Domestic water pipe crossing work	–	1 + 294	–	D75mm x L: 4.m	Use existing one
45	Washing basin (No.9)	–	1 + 300	Right bank	L: 2.5m x H: 0.45m x 3steps	Overall repairing
46	Washing basin (No.10)	–	1 + 350	Left bank	L: 1.0m x H: 0.3m x 1step	Overall repairing
47	Wooden footbridge (No.5)	–	1 + 375	–	log: 1piece + board: 1pc. x L: 3.0m	Overall restoration
48	Washing basin (No.11)	–	1 + 380	Left bank	L: 1.0m x H: 0.3m x 1step	Overall repairing
49	Lining B.P.	–	1 + 420	–		
50	Washing basin (No.12)	–	1 + 485	Left bank	L: 4.5m x H: 0.4m x 3steps	Overall repairing
51	Drainage inlet work (No.1)	–	1 + 490	Left bank	W: 1.0m x H: 0.7m	Use existing one
52	Turn out (No.5)	BM-6	1 + 527	–		Overall rehabilitation

Note) Use existing one, Overall restoration, Overall repairing and Overall rehabilitation in the column of remarks are based on the site observation. Hence, it will be re-examined in the homework in Japan.

Proposed Ramaskora Secondary Canal

No.	Name of Structure	No. of Structure	Station	Location	Elements	Remarks
1	B.P. of Sec. Canal	–	0 + 000	–	B: 2.4m x H: 1.1m x N: 1.0	Trapezoidal canal, paved with block (W= 1m)
2	Concrete bridge	–	0 + 050	–	W: 3.5m x L: 4.0m	Use existing one, exclusive of concrete block factory
3	Domestic water intake (No.1)	–	0 + 060	Left bank	D38mm pipe	Use existing structure
4	Washing basin (No.1,No.2)	–	0 + 075	Both banks	L: 1.0m x H: 0.4m x 2steps	Overall repairing, same scale for both banks
5	Washing basin (No.3)	–	0 + 080	Left bank	L: 3.5m x H: 0.3m x 3steps	Overall repairing, raised by 0.3m at downstream 5m
6	Wooden footbridge(No.1)	–	0 + 083	–	Divided log 1piece	Overall restoration
7	Wooden footbridge(No.2)	–	0 + 140	–	Divided log 2pieces	Overall restoration
8	Wooden footbridge(No.3)	–	0 + 150	–	Divided log 1piece	Overall restoration
9	Damaged lining B.P.	–	0 + 170	–	slope length : 1.4m	Restoration : 100%
10	Village road bridge (concrete)	–	0 + 215	–	W: 2.7m x L: 3.7m	Use existing structure
11	Washing basin (No.4)	–	0 + 220	Right bank	L: 1.0m x H: 0.3m x 1step	Overall repairing
12	Washing basin (No.5)	–	0 + 230	Left bank	L: 2.50m x H: 0.25m x 3steps	Overall repairing
13	Washing basin (No.6)	–	0 + 235	Right bank	L: 2.0m x H: 0.4m x 2steps	Overall repairing
14	Village bridge (concrete)	BRa-1	0 + 215	–	W: 2.7m x L: 3.7m	Use existing structure
15	Mun.road bridge (concrete)	BRa-2	0 + 272	–	W: 7.5m x L: 4.0m	Use existing structure
16	Washing basin (No.7)	–	0 + 290	Right bank	L: 1.5m x H: 0.3m x 2steps	Overall repairing
17	Drainage crossing work (No.1)	–	0 + 330	Left→Right bank	Corrugate pipe D1,000mm x 1series → □ 700x700 traversing canal	Partial repairing : wet masonry around outlet、H: 3.5m x L: 13.0m x 2sites
18	Washing basin (No.8)	–	0 + 345	Left bank	L: 7.0m x H: 0.3m x 3steps	Overall repairing
19	Turn out (No.1)	BRa-3	0 + 355	Right bank	Tertiary canal W: 0.7m x H: 1.2m	Overall restoration
20	Wooden footbridge(No.4)	–	0 + 400	–	Wooden board 0.3m thick 1 piece	Overall rehabilitation
21	Concrete bridge	–	0 + 410	–	W: 3.5m x L: 2.5m	Use existing one, exclusive by creditors (narrowed section)
22	Concrete bridge	–	0 + 420	–	W: 1.9m x L: 2.8m	Use existing one, exclusive for private use (narrowed section)
23	Bridge-type washing basin(No.1)	–	0 + 425	–	W: 0.7m x L: 2.0m	Overall rehabilitation
24	Aquaculture pond (No.1)	–	0 + 430	Right bank	pond : W: 2.0m x L: 3.5m	Use existing one H: 0.4m (water depth : 0.2m)
25	Washing basin (No.9)	–	0 + 450	Left bank	L: 2.0m x H: 0.3m x 3steps	Overall repairing
26	Washing basin (No.10)	–	0 + 452	Right bank	L: 2.0m x H: 0.3m x 3steps	Overall repairing
27	Wooden footbridge(No5)	–	0 + 455	–	W: 2.0m x L: 2.5m	Overall restoration
28	Vertical drop (No.1)	BRa-4	0 + 470	–	⊿H: 1.4m x W: 2.1m	Overall rehabilitation
29	Washing basin (No.11)	–	0 + 540	Left bank	L: 1.5m x H: 0.3m x 2steps	Overall repairing
30	Wooden footbridge(No6)	–	0 + 545	–	W: 2.5m x L: 3.5m x log 12pieces	Overall restoration
31	Wooden footbridge(No7)	–	0 + 555	–	Log 2pieces	Overall restoration
32	Corrugated bridge (No.8)	–	0 + 560	–	W: 1.0m x L: 3.0m	Use existing one, exclusive for private use
33	Washing basin (No.12)	–	0 + 562	Right bank	L: 2.0m x H: 0.3m x 1step	Overall repairing
34	Wooden footbridge(No9)	–	0 + 580	–	W: 2.0m x L: 2.5m, paved by log	Overall restoration
35	Washing basin (No.13)	–	0 + 590	Left bank	L: 1.5m x H: 0.3m x 2steps	Overall repairing
36	Washing basin (No.14)	–	0 + 590	Right bank	L: 0.8m x H: 0.3m x 2steps	Overall repairing
37	Concrete bridge	–	0 + 591	–	W: 2.5m x L: 2.5m	Use existing one, exclusive for private use (narrowed section)
38	Wooden footbridge (No10)	–	0 + 600	–	W: 1.0m x L: 2.5m, some pieces log	Overall restoration
39	Washing basin (No.15)	–	0 + 605	Left bank	L: 1.8m x H: 0.3m x 3steps	Overall repairing
40	Washing basin (No.16)	–	0 + 606	Right bank	L: 1.8m x H: 0.3m x 3steps	Overall repairing
41	Wooden footbridge (No11)	–	0 + 610	–	W: 0.8m x L: 2.5m, log 6pieces	Overall restoration
42	Concrete bridge	–	0 + 615	–	W: 3.0m x L: 2.0m	Use existing one, exclusive for private use (narrowed section)
43	Concrete bridge	–	0 + 660	–	W: 3.0m x L: 3.5m	Use existing one, exclusive for private use
44	Wooden footbridge (No12)	–	0 + 690	–	W: 1.0m x L: 3.0m, log 5 pieces	Overall restoration
45	Wooden footbridge (No13)	–	0 + 700	–	2pieces of log	Overall restoration
46	Washing basin (No.17)	–	0 + 705	Left bank	L: 3.5m x H: 0.2m x 5steps	Overall repairing
47	Turn out (No.2～4)	BRa-5	0 + 710	Both banks	Right bank :2sites, left bank:1site	Overall restoration, right bank drainage inlet: 1 site
48	Flume canal B.P.	–	0 + 727	–	W: 1.0m x H: 0.8m	Use existing structure, longitudinal wet masonry
49	Wooden footbridge (No14)	–	0 + 767	–	W: 2.5m x L: 1.0m	Use existing structure
50	Footbridge by cube pipes	–	0 + 777	–	W: 0.45m x L: 1.0m x 3pieces	Use existing structure
51	Washing basin (No.18)	–	0 + 778	–	L: 0.8m x H: 0.45m x 1step	Use existing structure
52	Washing basin (No.19, 20)	–	0 + 807	Both banks	L: 1.1m x H: 0.25m x 3steps	Use existing structure, same scale for left and right banks
53	Drainage inlet (No.1)	BRa-6	0 + 812	Right bank	W: 0.5m x H: 0.8m x T: 0.3m	Use existing structure
54	Irrigation crossing pipe (No.1)	–	0 + 850	–	D50mm x L: 10m, vinyl-chloride pipe	Use existing structure
55	Vertical drop (No.2)	–	0 + 956	–	⊿H: 1.2m x W: 0.9m	Use existing structure
56	Washing basin (No.21)	–	1 + 041	Left bank	L: 1.5m x H: 0.25m x 3steps	Use existing structure
57	Drainage inlet (No.2)	–	1 + 045	Right bank	W: 0.3m x H: 0.2m	Use existing structure, abundant water quantity
58	Flume canal E.P.	–	1 + 090	–	W: 1.0m x H: 0.8m	Use existing structure, longitudinal wet masonry
59	Concrete bridge for piste	–	1 + 140	–	W: 2.5m x L: 3.5m	Use existing structure, BRa-7b not found
60	Concrete bridge for piste	–	1 + 250	–	W: 3.5m x L: 2.5m	Use existing structure
61	Wooden footbridge (No15)	–	1 + 280	–	4 pieces of log	Overall restoration
62	Wooden footbridge (No16)	–	1 + 295	–	4 pieces of log	Overall restoration
63	Washing basin (No.22)	–	1 + 310	Left bank	L: 1.0m x H: 0.25m x 3steps	Overall repairing
64	Wooden footbridge (No17)	–	1 + 325	–	W: 1.5m x L: 3.5m	Overall restoration
65	Wooden footbridge (No18)	–	1 + 340	–	W: 1.0m x L: 3.5m	Overall restoration
66	Washing basin (No.23)	–	1 + 345	Right bank	L: 1.5m x H: 0.4m x 1step	Use existing structure

No.	Name of Structure	No. of Structure	Station	Location	Elements	Remarks
67	Wooden footbridge (No19)	–	1 + 360	–	W: 1.0m x L: 3.0m	Overall restoration
68	Washing basin (No.24)	–	1 + 365	Right bank	L: 1.0m x H: 0.25m x 2steps	Use existing structure
69	Wooden footbridge (No20)	–	1 + 380	–	W: 1.0m x L: 3.0m	Overall restoration
70	Washing basin (No.25)	–	1 + 385	Right bank	L: 1.5m x H: 0.25m x 2steps	Use existing structure
71	Wooden footbridge (No21)	–	1 + 400	–	1 pieces of cut in half log	Overall restoration
72	Washing basin (No.26)	–	1 + 420	Right bank	L: 1.0m x H: 0.25m x 2steps	Use existing structure
73	Wooden footbridge (No22)	–	1 + 430	–	W: 1.0m x L: 2.5m	Overall restoration
74	Wooden footbridge (No23)	–	1 + 435	–	W: 1.0m x L: 2.5m	Overall restoration
75	Wooden footbridge (No24)	–	1 + 450	–	W: 1.0m x L: 2.5m	Overall restoration
76	Turn out (No.5)	BRa-8	1 + 470	Right bank	Tertiary canal W: 0.4m x H: 1.0m	Overall rehabilitation, secondary canal W: 0.4m x H: 1.0m
77	Wooden footbridge (No25)	–	1 + 480	–	Board W: 0.3m x L:1.5m x 1sheet	Overall restoration
78	Wooden footbridge (No26)	–	1 + 490	–	Board W: 0.2m x L:2.5m x 2sheets	Overall restoration
79	Wooden footbridge (No27)	–	1 + 500	–	W: 1.5m x L: 2.5m	Overall restoration
80	Washing basin (No.27)	–	1 + 502	Right bank	L: 1.5m x H: 0.25m x 1step	Overall repairing
81	Wooden footbridge (No28)	–	1 + 515	–	W: 1.8m x L: 2.5m	Overall restoration
82	Wooden footbridge (No29)	–	1 + 540	–	W: 1.2m x L: 2.5m	Overall restoration
83	Corrugated bridge (No.30)	–	1 + 560	–	W: 3.5m x L: 2.0m	Overall restoration
84	Turn out (6)/vertical drop(3)	BRa-9	1 + 570	Left bank	Tertiary canal W: 0.3m x H: 0.85m	Tertiary canal, secondary canal W: 0.9m x H: 0.85m
85	Piste concrete bridge(No.31)	–	1 + 605	–	W: 5.0m x L: 3.0m	Use existing structure
86	Wooden footbridge (No32)	–	1 + 905	–	Board W: 0.2m x L:2.0m x 2sheets	Overall restoration
87	Turn out (No.7)	–	1 + 915	Right bank	Tertiary canal W: 0.5m x H: 0.3m	Tertiary canal, secondary canal W: 0.9m x H: 0.5m
88	Turn out (No.8)	–	1 + 930	Both banks	Tertiary (right) W: 0.45m x H: 0.3m	Tertiary canal, tertiary (left) W: 0.3m x H: 0.5m
89	Lining B.P.	–	2 + 115	–	W: (0.4～0.8)m x H: 0.6m	Trapezoidal section lining canal
90	Turn out (No.9)	–	2 + 165	Left bank	Tertiary canal W: 1.0m x H: 0.6m	Tertiary canal, use existing road crossing work (L=5m)
91	Turn out (No.10)	–	2 + 415	Right bank	Tertiary canal W: 1.0m x H: 0.3m(earth)	Tertiary canal
92	Paddy field drain inlet (3)	–	2 + 440	Right bank	W: 0.5m x H: 0.4m (earthen canal)	Tertiary canal
93	Lining E.P.	–	2 + 490	–	W: 0.4～0.8m x H: 0.6m	Trapezoidal section lining canal
94	Turn out (No.11)	–	2 + 500	Right bank	Tertiary canal W: 1.0m x H: 0.3m(earth)	Tertiary canal、
95	Turn out (No.12)	–	2 + 660	Left bank	Tertiary canal W: 1.0m x H: 0.6m	Tertiary canal, use existing road crossing work (L=5m)
96	Turn out (No.13)	–	2 + 685	Right bank	Tertiary canal W: 1.0m x H: 0.3m(earth)	Tertiary canal、
97	Piste bridge (No.33)	–	2 + 795	–	W: 5m x L: (0.4～0.8)m x H:0.6m	Use existing structure
98	Turn out (No.14)	–	2 + 815	Left bank	Tertiary canal W: 1.0m x H: 0.6m	Tertiary canal, use existing road crossing work (L=5m)
99	Lining B.P.	–	2 + 925	–	W: 0.4～0.8m x H: 0.6m	Trapezoidal section lining canal
100	Turn out (No.15, 16)	–	2 + 990	Both banks	Tertiary canal W: 1.0m x H: 0.2m(earth)	Tertiary canal, tertiary (left), road crossing work D800mm
101	Lining E.P.	–	3 + 020	–	W: 0.4～0.8m x H: 0.6m	Trapezoidal section lining canal
102	Wooden footbridge (No34)	–	3 + 090	–	4 pieces of log	Overall restoration
103	Lining B.P.	–	3 + 175	–	W: 0.4～0.8m x H: 0.6m	Trapezoidal section lining canal
104	Turn out (No.17)	–	3 + 305	Left bank	Tertiary canal W: 0.7m x H: 0.6m	Tertiary canal, use existing road crossing work (L=5m)
105	Turn out (No.18)	–	3 + 460	Right bank	Tertiary canal W: 1.0m x H: 0.3m(earth)	Tertiary canal
106	Turn out (No.19)	–	3 + 650	Left bank	Tertiary canal W: 0.8m x H: 0.35m	Tertiary canal, use existing road crossing work (L=5m)
107	Turn out (No.20)	–	3 + 945	Left bank	Tertiary canal W: 0.6m x H: 0.3m	Tertiary canal, use existing road crossing work (L=5m)
108	Turn out (No.21)	–	4 + 095	Right bank	Tertiary canal W: 1.0m x H: 0.3m(earth)	Tertiary canal
109	Road crossing work	–	4 + 100	–	W: 0.6m x H: 0.7m x L: 5.0m	Use existing structure
110	Turn out (No.22)	–	4 + 650	Right bank	Tertiary canal W: 0.6m x H: 0.3m	Tertiary canal、Secondary canal W: 0.8m x H: 0.3m

Proposed Ritabau Secondary Canal Structure

No.	Name of Structure	No. of Structure	Station	Location	Elements	Remarks
1	Secondary canal B.P.	—	0 + 000	—	B: 0.95m x H: 0.6m x N: 1.0	Trapezoidal canal
2	Wooden footbridge (No.1)	—	0 + 050	—	Square wood 1pieces x L: 3.0m	Overall restoration
3	Turn out (No.1)	BRi-1	0 + 070	Left bank	Tertiary canal W: 0.3m x H: 0.95m	Overall rehabilitation、secondary canal W: 1.0m x H: 1.0m
4	Turn out(2)/Vertical drop work(1)	BRi-2	0 + 210	Right bank	Tertiary canal W: 0.35m x H: 1m	Overall rehabilitation、Vertical drop work ⊿H: 1.65m
5	Washing basin (No.1)	—	0 + 295	Right bank	L: 2.3m x H: 0.35m x 1steps	Overall repairing、
6	Wooden footbridge (No.2)	—	0 + 296	—	W: 0.2m wooden board 1sheets x L: 2.5m	Overall restoration
7	Wooden footbridge (No.3)	—	0 + 340	—	log 1pieces x L: 2.5m	Overall restoration, bridge for sheep passage: W: 2.0m(requested)
8	Turn out (No.3)	—	0 + 500	Left bank	Tertiary canal pipe D100mm	Overall rehabilitation
9	Wooden footbridge (No.4)	—	0 + 530	—	W: 0.3m wooden board 1sheets x L: 2.5m	Overall restoration
10	Washing basin (No.2, 3)	—	0 + 595	Left & Right bank	(right) L: 1.5m x H: 0.3m x 2steps	Overall repairing, (left) L: 1.4mxH:0.3mx2step
11	Wooden bridge (No.5)	—	0 + 600	—	W: 1.0m x L: 3.5m (high position)	Overall restoration
12	Village road bridge (wooden,No.6)	—	0 + 755	—	W: 2.6m x L: 2.0m	Conversion into concrete bridge
13	Rapid flow work (No.1)	BRi-3	0 + 760	—	W: 1.0m x H: 1.0m x L: 47.5m	Overall rehabilitation, drop height ⊿H: 5.4m, gradient 1/8.8
14	Turn out (No.4)	BRi-3	0 + 770	Right bank	Tertiary canal W: 0.5m x H: 0.65m	Overall rehabilitation
15	Turn out (No.5)	BRi-3	0 + 781	Left bank	Tertiary canal W: 0.5m x H: 0.65m	Overall rehabilitation
16	Turn out (No.6)	—	0 + 803	Left bank	Tertiary canal W: 0.6m x H: 0.3m(Drainage crossing work)	Overall rehabilitation
17	Vertical drop work(No.2)	BRi-4	0 + 805	—	⊿H: 1.05m x W: 1.1m	Overall rehabilitation
18	Turn out (No.7)	—	0 + 850	Right bank	Tertiary canal W: 0.7m x H: 0.55m (Drainage crossing work)	Overall rehabilitation
19	Washing basin (No.8)	—	0 + 345	Left bank	L: 7.0m x H: 0.3m x 3step	Overall repairing
20	Vertical drop work(No.3)	BRi-5	0 + 902	—	⊿H: 1.5m x W: 1.1m	Overall rehabilitation
21	Wooden footbridge (No.7)	—	0 + 980	—	W: 0.6m x L: 3.5m(board sheets)	Overall restoration
22	Washing basin (No.4)	—	1 + 020	Left bank	L: 1.5m x H: 0.3m x 2steps	Overall repairing、
23	Vertical drop work(No.4)	BRi-6	1 + 025	—	⊿H: 1.7m x W: 1.0m	Overall rehabilitation, safety fence requested
24	Concrete bridge (No.8)	—	1 + 040	—	W: 2.7m x L: 4.0m	use existing one, exclusive private use
25	Wooden bridge (No.9)	—	1 + 060	—	W: 2.5m x L: 3.0m	Overall restoration, 15 households use it.
26	Wooden bridge (No.10)	—	1 + 070	—	W: 2.5m x L: 3.0m	Overall restoration, grocery shop uses it
27	Washing basin (No.5)	—	1 + 080	Left bank	L: 1.2m x H: 0.3m x 1step	Overall repairing
28	Concretefootbridge(No.11)	—	1 + 085	—	W: 2.3m x L: 2.9m	Use existing one, exclusive private use
29	Domestic water pipe crossing work (No.1)	—	1 + 100	—	D45mm Steel Pipe L: 3.0m	Use existing one
30	Wooden footbridge (No.12)	—	1 + 105	—	W: 1.5m x L: 2.0m	Overall restoration
31	Vertical drop work(No.5)	BRi-7	1 + 170	—	⊿H: 1.5m x W: 0.95m	Overall rehabilitation
32	Wooden footbridge (No.13)	—	1 + 185	—	W: 1.5m x L: 2.0m	Overall restoration
33	Wooden footbridge (No.14)	—	1 + 195	—	log 4 pieces x L: 3.0m	Overall restoration
34	Concrete bridge (No.15)	—	1 + 210	—	W: 2.3m x L: 3.3m	Use existing one, exclusive private use
35	Wooden footbridge (No.16)	—	1 + 225	—	log 3pieces x L: 3.0m	Overall restoration, domestic water pipe D50mm x 3.0m
36	Village road bridge(concreteNo.17)	—	1 + 255	—	W: 2.8m x L: 2.0m	Overall repairing
37	Wooden footbridge (No.18)	—	1 + 285	—	W: 1.3m x L: 2.5m	Overall restoration
38	Wooden footbridge (No.19)	—	1 + 290	—	W: 1.0m x L: 2.5m	Overall restoration
39	Wooden footbridge (No.20)	—	1 + 310	—	log 2pieces x L: 3.0m	Overall restoration
40	Wooden footbridge (No.21)	—	1 + 325	—	W: 2.0m x L: 2.5m、log 13pieces	Overall restoration
41	Wooden footbridge (No.22)	—	1 + 340	—	W: 1.2m x L: 2.0m、log 10pieces	Overall restoration
42	Domestic water pipe crossing work (No.2)	—	1 + 350	—	D25mmSteel Pipe L: 3.0m	Use existing one
43	Washing basin (No.6)	—	1 + 360	Right bank	L: 2.2m x H: 0.3m x 2step	Overall repairing
44	Wooden footbridge (No.23)	—	1 + 370	—	log 5pieces x L: 2.5m	Overall restoration
45	Turn out (No.8)	—	1 + 380	Left bank	Tertiary canal W: 0.55m x H: 0.9m (Drainage crossing work)	Overall rehabilitation
46	Washing basin (No.7)	—	1 + 398	Right bank	L: 1.2m x H: 0.3m x 1step	Overall repairing
47	Vertical drop work(No.6)	BRi-8	1 + 400	—	⊿H: 0.55m x W: 1.0m	Overall rehabilitation
48	Village road bridge(concreteNo.24)	BRi-8	1 + 405	—	W: 6.0m x L: 3.5m	Overall rehabilitation
49	Concrete bridge (No.25)	—	1 + 485	—	W: 2.4m x L: 3.0m	Use existing one, exclusive private use
50	Wooden footbridge (No.26)	—	1 + 535	—	log3pieces x L: 2.0m	Overall restoration
51	Washing basin (No.8)	—	1 + 550	Right bank	L: 1.8m x H: 0.3m x 1step	Overall repairing
52	Wooden footbridge (No.27)	—	1 + 553	—	log3pieces x L: 2.0m	Overall restoration
53	Wooden footbridge (No.28)	—	1 + 570	—	W: 1.0m x L: 2.0m、	Overall restoration
54	Concrete bridge (No.29)	—	1 + 590	—	W: 2.5m x L: 2.5m	use existing one, exclusive private use
55	Washing basin (No.9)	—	1 + 593	Right bank	L: 1.2m x H: 0.23m x 1step	Overall repairing
56	Wooden footbridge (No.30)	—	1 + 600	—	log3pieces x L: 2.0m	Overall restoration
57	Washing basin (No.10)	—	1 + 620	Right bank	L: 1.3m x H: 0.35m x 1step	Overall repairing
58	Wooden footbridge (No.31)	—	1 + 630	—	W: 1.0m x L: 2.0m	Overall restoration
59	Vertical drop work(No.7)	BRi-9	1 + 660	—	⊿H: 0.9m x W: 0.6m	Partial repairing
60	Wooden footbridge (No.32)	—	1 + 670	—	W: 1.0m x L: 2.0m、log 8pieces	Overall restoration
61	Drainage inlet work (No.1)	—	1 + 680	Right bank	D100mm pipe new construction	Overall rehabilitation
62	Wooden footbridge (No.33)	—	1 + 673	—	W: 1.0m x L: 2.0m、board3sheets	Overall restoration
63	Wooden footbridge (No.34)	—	1 + 700	—	W: 1.8m x L: 2.0m, fixed board	Overall restoration
64	Washing basin (No.11)	—	1 + 705	Right bank	L: 1.5m x H: 0.35m x 1step	Overall repairing
65	Washing basin (No.12)	—	1 + 720	Right bank	L: 1.0m x H: 0.3m x 1step	Overall repairing
66	Private house over canal (No.1)	—	1 + 730	—	W: 2.6m x L: 2.6m x H: 2.1m	Overall restoration
67	Concrete bridge (No.35)	—	1 + 740	—	W: 5.0m x L: 2.9m, partial repairing	use existing one, 9 households use it
68	Private house over canal (No.2)	—	1 + 750	—	W: 4.8m x L: 4.5m x H: 2.1m	Overall restoration
69	Washing basin (No.13)	—	1 + 760	Right bank	L: 1.3m x H: 0.3m x 1step	Overall repairing
70	Wooden footbridge (No.35)	—	1 + 765	—	W: 0.1m board x L:2.0m x 6sheets	Overall restoration
71	Wooden footbridge (No.36)	—	1 + 780	—	log 2pieces x L: 2.0m	Overall restoration
72	Wooden footbridge (No.37)	—	1 + 790	—	log 9pieces x L: 2.0m	Overall restoration
73	Wooden footbridge (No.38)	—	1 + 840	—	W: 2.0m x L: 2.0m, log 16pieces	Overall restoration

No.	Name of Structure	No. of Structure	Station	Location	Elements	Remarks
74	Wooden footbridge (No.39)	−	1 + 860	−	W: 1.2m x L: 2.0m, board 7sheets	Overall restoration
75	Wooden footbridge (No.40)	−	1 + 870	−	log 1pieces x L: 2.0m	Overall restoration
76	Washing basin (No.14)	−	1 + 885	Left bank	L: 1.0m x H: 0.3m x 1step	Overall repairing
77	Concrete bridge (No.41)	−	1 + 900	−	W: 3.0m x L: 2.5m	use existing one but partially repairing
78	Washing basin (No.15)	−	1 + 905	Right bank	L: 1.2m x H: 0.2m x 1step	Overall repairing
79	Wooden footbridge (No.42)	−	1 + 920	−	W: 0.8m x L: 1.5m	Overall restoration、board 2sheets+log 1pieces
80	Washing basin (No.16)	−	1 + 950	Right bank	L: 2.0m x H: 0.3m x 1step	Overall repairing
81	Concrete bridge (No.43)	−	1 + 955	−	W: 2.2m x L: 2.1m	use existing one but partially repairing
82	Wooden footbridge (No.44)	−	1 + 970	−	W: 1.2m x L: 2.0m、board 5sheets	Overall restoration
83	Turn out (No.9)	BRi-10	1 + 999	Right bank	tertiary canal W: 0.5m x H: 0.4m	Overall rehabilitation
84	Homestead crossing work (No.1)	BRi-10	2 + 006	−	W: 0.8m x L: 0.6m	use existing one
85	Road crossing work(No.1)	BRi-10	2 + 012	−	W: 0.8m x H: 0.6m x L: 7.5m	use existing one but partially repairing
86	Turn out (No.10)	BRi-10	2 + 020	Left bank	tertiary canal W: 0.3m x H: 0.55m	Overall rehabilitation, secondary canal W: 0.75m x H: 0.65m
87	Wooden footbridge (No.45)	−	2 + 050	−	W: 0.2m board x L:2.5m x 3sheets	Overall restoration
88	Wooden footbridge (No.46)	−	2 + 070	−	W: 1.0m x L: 2.5m、	Overall restoration
89	Wooden footbridge (No.47)	−	2 + 085	−	W: 0.3mのboard x L:2.5m x	Overall restoration
90	Vertical drop work (No.8)	BRi-11	2 + 121	−	⊿H: 1.5m x W: 0.8m	Overall rehabilitation
91	Wooden footbridge (No.48)	−	2 + 200	−	W: 1.5m x L:2.0m、board5sheets	Overall restoration
92	Washing basin (No.17)	−	2 + 201	Right bank	L: 1.0m x H: 0.2m x 2step	Overall repairing
93	Wooden footbridge (No.48)	−	2 + 215	−	log L:2.5m x 3pieces	Overall restoration
94	Wooden footbridge (No.49)	−	2 + 230	−	board L:2.5m x 4sheets	Overall restoration
95	Washing basin (No.18)	−	2 + 231	Left bank	L: 1.0m x H: 0.2m x 1step	Overall repairing
96	Wooden footbridge (No.50)	−	2 + 300	−	W: 2.5m x L:2.0m	Overall restoration
97	Vertical drop work (No.9)	BRi-12	2 + 319	−	⊿H: 0.5m x W: 0.9m	Overall rehabilitation
98	Washing basin (No.19)	−	2 + 370	Left bank	L: 1.2m x H: 0.35m x 2step	Overall repairing
99	Wooden footbridge (No.51)	−	2 + 375	−	W: 2.5m x L:2.5m	Overall restoration
100	Wooden footbridge (No.52)	−	2 + 390	−	log L:2.5m x 3pieces	Overall restoration
101	Village road bridge (wooden,No.53)	−	2 + 400	−	W: 2.0m x L:2.0m、	Overall restoration
102	Washing basin (No.20)	−	2 + 410	Right bank	L: 1.3m x H: 0.25m x 1step	Overall repairing
103	Washing basin (No.21)	−	2 + 450	Left bank	L: 0.8m x H: 0.15m x 1step	Overall repairing
104	Washing basin (No.22)	−	2 + 465	Left bank	L: 1.3m x H: 0.25m x 1step	Overall repairing
105	Wooden footbridge (No.54)	−	2 + 466	−	log L:2.5m x 1pieces	Overall restoration
106	Washing basin (No.23)	−	2 + 475	Right bank	L: 1.0m x H: 0.25m x 1step	Overall repairing
107	Vertical drop work (No.10)	BRi-13	2 + 480	−	⊿H: 1.3m x W: 0.8m	Overall rehabilitation
108	Washing basin (No.24)	−	2 + 560	Left bank	L: 1.0m x H: 0.25m x 1step	Overall repairing
109	Wooden footbridge (No.55)	−	2 + 565	−	W: 2.0m x L:2.0m、	Overall restoration
110	Wooden footbridge (No.56)	−	2 + 590	−	board L:2.0m x 2sheets	Overall restoration
111	Vertical drop work (No.11)	BRi-14	2 + 600	−	⊿H: 1.3m x W: 0.6m	Overall rehabilitation
112	Washing basin (No.25)	−	2 + 650	Left bank	L: 1.4m x H: 0.3m x 1stwp	Overall repairing
113	Wooden footbridge (No.57)	−	2 + 655	−	board L:2.5m x 6sheets	Overall restoration
114	Wooden footbridge (No.58)	−	2 + 685	−	board L:2.5m x 5sheets	Overall restoration
115	Wooden footbridge (No.59)	−	2 + 700	−	half log L: 2.5m x 3pieces	Overall restoration
116	Steel-made footbridge (No.60)	−	2 + 715	−	W: 2.0m x L:2.0m、	Overall restoration
117	Vertical drop work (No.12)	BRi-15	2 + 725	−	⊿H: 0.4m x W: 0.8m	Overall rehabilitation
118	Concretebridge(No.61)	−	2 + 765	−	W: 3.0m x L: 2.0m	Use existing one, exclusive use for school, partial repairing
119	Vertical drop work (No.13)	BRi-15a	2 + 770	−	⊿H: 0.3m x W: 0.8m	Overall rehabilitation
120	Wooden footbridge (No.62)	−	2 + 800	−	Square section log L: 2.0m x 3pieces	Overall restoration
121	Washing basin (No.26)	−	2 + 810	Right bank	L: 1.0m x H: 0.2m x 1step	Overall repairing
122	Concrete bridge (No.63)	−	2 + 820	−	W: 1.5m x L: 3.0m	use existing one, but partial repairing
123	Turn out (No.11)	BRi-16	2 + 831	Left bank	tertiary canal W: 0.25m x H: 0.75m	Overall rehabilitation、secondary canal W: 0.8m x H: 0.9m
124	Washing basin (No.27)	−	2 + 870	Left bank	L: 2.7m x H: 0.3m x 2step	Overall repairing
125	Road crossing work(No.2)	BRi-17	2 + 880	−	W: 1.2m x H: 0.6 x L: 4.5m (half circle section)	Overall repairing
126	Turn out (No.12)	BRi-17	2 + 890	Right bank	tertiary canal W: 0.45m x H: 0.85m	Overall rehabilitation、secondary canal W: 0.5m x H: 1.0m
127	Vertical drop work (No.14)	BRi-17	2 + 892	−	⊿H: 1.3m x W: 0.5m	Overall rehabilitation
128	Wooden footbridge (No.64)	−	2 + 925	−	W: 2.0m x L: 2.0m	Overall restoration
129	Wooden footbridge (No.65)	−	2 + 940	−	W: 1.0m x L: 2.0m、board 5sheets	Overall restoration
130	Vertical drop work (No.15)	−	2 + 955	−	⊿H: 1.0m x W: 0.55m	Overall rehabilitation
131	Wooden footbridge (No.66)	−	2 + 975	−	W: 2.5m x L: 2.0m, log 17pieces	Overall restoration
132	Concrete bridge (No.67)	−	3 + 070	−	W: 2.5m x L: 3.3m	use existing one, partial repairing
133	Wooden footbridge (No.68)	−	3 + 105	−	W: 2.5m x L: 2.0m, log 15pieces	Overall restoration
134	Wooden footbridge (No.69)	−	3 + 155	−	W: 1.0m x L: 2.0m, board 4 sheets	Overall restoration
135	Vertical drop work (No.16)	−	3 + 200	−	⊿H: 0.95m x W: 0.55m	Overall rehabilitation
136	Wooden footbridge (No.70)	−	3 + 340	−	W: 0.8m x L: 2.0m, log 4pieces	Overall restoration
137	Wooden footbridge (No.71)	−	3 + 360	−	Cut in half log L: 2.0m x 2pieces	Overall restoration
138	Wooden footbridge (No.72)	−	3 + 385	−	W: 1.2m x L: 2.0m, board 6sheets	Overall restoration
139	Wooden footbridge (No.73)	−	3 + 400	−	W: 1.8m x L: 2.0m, board 7 sheets	Overall restoration
140	Wooden footbridge (No.74)	−	3 + 455	−	Cut in half log L: 2.0m x 1piece	Overall restoration
141	Wooden footbridge (No.75)	−	3 + 510	−	W: 2.0m x L: 2.0m, log 11pieces	Overall restoration
142	Wooden footbridge (No.76)	−	3 + 565	−	W: 2.0m x L: 2.0m, log 14pieces	Overall restoration
143	Wooden footbridge (No.77)	−	3 + 575	−	log L: 3.0m x 1piece	Overall restoration
144	Wooden footbridge (No.78)	−	3 + 620	−	log L: 1.5m x 2pieces	Overall restoration
145	Drainage inlet work (No.2)	−	3 + 685	Left bank	W: 0.6m x H: 0.6 x L: 5.0m	Inflow box by new construction, road crossing work：partial repairing
146	Wooden footbridge (No.79)	−	3 + 735	−	W: 2.5m x L: 2.0m, log 14 pieces	Overall restoration
147	Wooden footbridge (No.80)	−	3 + 750	−	W: 2.0m x L: 2.0m, log 12 pieces	Overall restoration
148	Turn out (No.13)	−	3 + 760	Right bank	tertiary canal W: 0.4m x H: 0.65m	Overall rehabilitation、secondary canal W: 1.0m x H: 0.6m
149	Wooden footbridge (No.81)	−	3 + 780	−	W: 2.0m x L: 2.5m, log 14 pieces	Overall restoration
150	Drainage inlet work (No.3)	−	3 + 805	Left bank	W: 0.6m x H: 0.7 x L: 5.0m	Inflow box by new construction, road crossing work：partial repairing
151	Wooden footbridge (No.82)	−	3 + 815	−	W: 3.5m x L: 2.5m, J132, log 20pieces	Overall restoration

No.	Name of Structure	No. of Structure	Station	Location	Elements	Remarks
152	Turn out (No.14)	－	3 + 830	Right bank	tertiary canal W: 0.3m x H: 0.8m	new construction
153	Wooden footbridge (No.83)	－	3 + 845	－	W: 2.0m x L: 1.5m, log 18pieces	Overall restoration
154	Wooden footbridge (No.84)	－	3 + 895	－	W: 2.5m x L: 2.0m, log 14 pieces	Overall restoration
155	Turn out (No.15)	－	3 + 905	Right bank	tertiary canal W: 0.5m x H: 0.2m	new construction
156	Wooden footbridge (No.85)	－	3 + 945	－	W: 2.5m x L: 2.0m, log 12 pieces	Overall restoration
157	dDrainage inlet work (No.4)	－	3 + 980	Left bank	W: 0.6m x H: 0.4 x L: 5.0m	new construction for inlet box, partial repairing for road crossing work
158	Turn out (No.16)	－	4 + 060	Right bank	tertiary canal W: 0.25m x H: 0.7m	Overall rehabilitation、secondary canal W: 0.3m x H: 0.7m
159	Wooden footbridge (No.86)	－	4 + 130	－	log L: 2.0m x 2 pieces	Overall restoration
160	Turn out (No.17)	－	4 + 145	Right bank	tertiary canal W: 0.25m x H: 0.8m	Overall rehabilitation、secondary canal W: 0.3m x H: 0.8m
161	Wooden footbridge (No.87)	－	4 + 170	－	log L: 2.0m x 2pieces	Overall restoration
162	Turn out (No.18)	－	4 + 260	Right bank	tertiary canal W: 0.5m x H: 0.2m(Drainage crossing work)	new construction、secondary canal W: 0.6m x H: 0.3m
163	Turn out (No.19)	－	4 + 295	Right bank	tertiary canal W: 0.3m x H: 0.2m(Drainage crossing work)	new construction、secondary canal W: 0.6m x H: 0.3m
164	Wooden footbridge (No.88)	－	4 + 295	－	board (W:0.3m) x L: 2.5m x	Overall restoration
165	Turn out (No.20)	－	4 + 365	Right bank	tertiary canal W: 0.3m x H: 0.2m(Drainage crossing work)	new construction、secondary canal W: 0.6m x H: 0.3m
166	Wooden footbridge (No.89)	－	4 + 385	－	W: 2.0m x L: 1.5m, log 11pieces	Overall restoration
167	Wooden footbridge (No.90)	－	4 + 420	－	W: 2.5m x L: 2.0m	Overall restoration
168	Turn out (No.21)	－	4 + 470	Right bank	tertiary canal W: 0.4m x H: 0.3m(Drainage crossing work)	new construction、secondary canal W: 0.6m x H: 0.3m
169	Wooden footbridge (No.91)	－	4 + 510	－	board (W:0.3m) x L: 2.5m x	Overall restoration
170	Wooden footbridge (No.92)	－	4 + 530	－	board (W:0.5m) x L: 2.5m x	Overall restoration
171	Wooden footbridge (No.93)	－	4 + 565	－	board (W:0.3m) x L: 2.0m x	Overall restoration
172	Turn out (No.22)	－	4 + 580	Right bank	tertiary canal W: 0.5m x H: 0.2m(Drainage crossing work)	new construction、secondary canal W: 0.6m x H: 0.3m
173	Turn out (No.23)	－	4 + 650	Right bank	tertiary canal W: 0.3m x H: 0.2m(Drainage crossing work)	new construction、secondary canal W: 0.6m x H: 0.3m
174	Turn out (No.24)	－	4 + 775	Right bank	tertiary canal W: 0.5m x H: 0.2m(Drainage crossing work)	new construction、secondary canal W: 0.6m x H: 0.3m
175	Turn out (No.25)	－	4 + 835	Left bank	Tertiary: 1.0m x H: 0.6m x L: 4.5m	new construction for inflow box, partial repairing for crossing work
176	Drainage inlet work (No.5)		4 + 875	Left bank		
177	Road crossing work (No.3)		5 + 145			
178	Turn out (No.26)	－	5 + 250	Left bank		

(1) Present Cropping Pattern (Paddy Only)

Pattern 1:

Paddy 105-day variety
Present situation
Irrigation period:105 days

Cropping pattern	season Rainy	Dry
Upstream: Main and Ramaskora and Ritabou 2ndary, upstream	30%	60%
Midstream: Ramskora and Ritabau 2ndary, midstream	30%	40%
Downstream: Ramskora and Ritabau 2ndary, downdstream	40%	0%

Percolation rate (water requirement rate measurement)

Up/Midstream:	3.0mm/day
Downstream:	5.0mm/day

Water requirement for land preparation (including ponding depth 50mm/month)

land preparation period:	1 month
beginning of rainy season crop:	300mm
beginning of dry season crop:	250mm

Water Layer Replacement(WLR):WB F/S report
50mm/15day

Irrigation efficiency (FAO criteria)

Application efficiency(Ea)	Ea=0.80
Branch canal efficiency(Eb)	Eb=0.80
Farm efficiency(Ef=Ea x Eb)	Ef=0.64
Conveyance efficiency(Ec)	Ec=0.65
Irrigation(Project) efficiency(Ep=Ef x Ec)	Ep=0.416

Item	Unit	January		February		March		April		May		June		July		August		September		October		November		December		Total/AV
Discharge of Bulobo river Maximum average discharge:		4.60		5.60		4.50		3.70		1.90		1.40		1.10		0.80		0.60		0.50		1.40		3.00		1.70
Average discharge:		**2.00**		**2.50**		**2.20**		**1.70**		**1.10**		**0.90**		**0.60**		**0.40**		**0.30**		**0.20**		**0.70**		**1.20**		**1.20**
Minimum average discharge:		0.40		0.80		0.70		0.60		0.40		0.30		0.20		0.10		0.10		0.10		0.20		0.30		0.50
Low-flow reliability, 1 in 2 years:		1.73		2.02		2.30		1.56		1.06		0.84		0.62		0.39		0.26		0.23		0.47		1.05		1.04
Low-flow reliability, 1 in 3 years:		1.33		1.67		1.68		1.42		0.99		0.75		0.49		0.31		0.20		0.19		0.30		0.84		0.85
Low-flow reliability, 1 in 5 years:	(m3/sec)	**0.94**		**1.37**		**1.37**		**1.30**		**0.95**		**0.73**		**0.46**		**0.28**		**0.18**		**0.16**		**0.29**		**0.71**		**0.90**
1. Cropping pattern, Crop coefficient (kc)																										
1)Upstream 30% 60%		1.05	1.05	1.10	1.10	0.95	0.00	-		L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	-						L.P.	L.P.	
2)Midstream 30% 40%		L.P	1.05	1.05	1.10	1.10	0.95	0.00	-		L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	-						L.P.	
3)Downstream 40% 0%		L.P	L.P	1.05	1.05	1.10	1.10	0.95	0.00	-		L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	-						
2. Evapo-transpiration (ET_0)		**1.4**	**1.4**	**1.2**	**1.2**	**1.3**	**1.3**	**1.8**	**1.8**	**2.2**	**2.2**	**2.9**	**2.9**	**4.1**	**4.1**	**4.2**	**4.2**	**3.9**	**3.9**	**3.7**	**3.7**	**2.4**	**2.4**	**1.5**	**1.5**	
Crop evapo-transpiration rate ($ET_{crop}=kc \times ET_0$)																										
1)Upstream 30% 60%		0.4	0.4	0.4	0.4	0.4	0.0					1.8	1.8	2.7	2.7	2.4										
2)Midstream 30% 40%			0.4	0.4	0.4	0.4	0.5	0.0					1.2	1.7	1.8	1.8	1.6									
3)Downstream 40% 0%				0.5	0.5	0.6	0.6	0.7	0.0					0.0	0.0	0.0	0.0	0.0								
Total	(mm/day)	**0.4**	**0.9**	**1.3**	**1.3**	**1.4**	**1.1**	**0.7**	**0.0**	**0.0**	**0.0**	**1.8**	**3.0**	**4.4**	**4.5**	**4.2**	**1.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
3. Percolation rate																										
1)Upstream 30% 60% 3.0mm/day		0.9	0.9	0.9	0.9	0.9				1.8	1.8	1.8	1.8	1.8	1.8									0.9	0.9	
2)Midstream 30% 40% 3.0mm/day		0.9	0.9	0.9	0.9	0.9	0.9				1.2	1.2	1.2	1.2	1.2	1.2									0.9	
3)Downstream 40% 0% 5.0mm/day		2.0	2.0	2.0	2.0	2.0	2.0	2.0				0.0	0.0	0.0	0.0	0.0	0.0									
Total	(mm/day)	**3.8**	**3.8**	**3.8**	**3.8**	**3.8**	**2.9**	**2.0**	**0.0**	**1.8**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**1.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.9**	**1.8**	
4. Water requirment rate (2+3)	(mm/day)	**4.2**	**4.7**	**5.1**	**5.1**	**5.2**	**4.0**	**2.7**	**0.0**	**1.8**	**3.0**	**4.8**	**6.0**	**7.4**	**7.5** Max.	**5.4**	**1.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.9**	**1.8**	
5. Net water requirement for land preparation (source:WB F/S)																										
1)Upstream 30% 60% Rainy season: 17.3mm/day										7.6	7.6													4.3	4.3	
2)Midstream 30% 40% Dry season: 15.6mm/day		4.3									5.0	5.0													4.3	
3)Downstream 40% 0%		4.9	4.9									0.0	0.0													
Total	(mm/day)	**9.2**	**4.9**	**0.0**					**0.0**	**7.6**	**12.6**	**5.0**											**0.0**	**4.3**	**8.6**	
6. Water Layer Replacement: WLR																										
1)Upstream 30% 60% 10.3mm/day				3.1										6.2												
2)Midstream 30% 40%					3.1										4.1											
3)Downstream 40% 0%						4.1										0.0										
Total	(mm/day)		**0.0**	**3.1**	**3.1**	**4.1**	**0.0**						**0.0**	**6.2**	**4.1**											
7. Total farm water requirement (4+5+6)	(mm/day)	**13.4**	**9.6**	**8.2**	**8.2**	**9.3**	**4.0**	**2.7**	**0.0**	**9.4**	**15.6**	**9.9**	**6.0**	**13.6**	**11.6**	**5.4**	**1.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.2**	**10.4**	**144.0**
																						annual water requirement(mm)				**2,160**
8. Effective rainfall (source:WB F/S)																										
1) Agerage rainfall per month		380		362		312		120		100		43		12		12		13		78		208		305		1,945
2) Low-rainfall reliability, 1 in 5 years (reliability more than 80%)		106	117	106	92	76	81	13	13	12	13	0	0	0	0	0	0	0	0	10	11	45	45	95	152	987
3) Effective rainfall (80% of low-rainfall reliability, 1 in 5 years)		85	94	85	74	61	65	10	10	10	10	0	0	0	0	0	0	0	0	8	9	36	36	76	122	790
4) Effective rainfall per day	(mm/day)	**5.7**	**6.2**	**5.7**	**4.9**	**4.1**	**4.3**	**0.7**	**0.7**	**0.6**	**0.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**0.6**	**2.4**	**2.4**	**5.1**	**8.1**	
																						annunal net water requirement(mm)				
9. Net water requirement(7-8)	(mm/day)	**7.8**	**3.3**	**2.5**	**3.3**	**5.3**	**0.0**	**2.0**	**0.0**	**8.7**	**14.9**	**9.9**	**6.0**	**13.6**	**11.6**	**5.4**	**1.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**2.2**	**1,475**
unit net water requirement	(lit/sec/ha)	**0.90**	**0.39**	**0.29**	**0.38**	**0.61**	**0.00**	**0.23**	**0.00**	**1.01**	**1.72**	**1.14**	**0.70**	**1.58**	**1.35**	**0.63**	**0.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.26**	
10. Unit diversion requirement at offtakes from 2ndary canal Farm efficiency: Ef=0.64	(lit/sec/ha)	**1.40**	**0.60**	**0.46**	**0.59**	**0.95**	**0.00**	**0.36**	**0.00**	**1.58**	**2.69**	**1.78**	**1.09**	**2.46**	**2.11**	**0.98**	**0.29**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.41**	
11. Unit diversion requirement at intake Conveyance efficiency: Ec=0.65	(lit/sec/ha)	peak **2.16**	**0.93**	**0.70**	**0.92**	**1.46**	**0.00**	**0.55**	**0.00**	**2.42**	peak **4.14**	**2.74**	**1.68**	**3.79**	**3.24**	**1.51**	**0.44**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.03**	**0.62**	
12. Diversion requirement at intake **100ha**	**(m3/sec)**	0.22	0.09	0.07	0.09	0.15	0.00	0.06	0.00	0.24	0.41	0.27	0.17	0.38	0.32	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	
Irrigation area: **150ha**	**(m3/sec)**	0.32	0.14	0.11	0.14	0.22	0.00	0.08	0.00	0.36	0.62	0.41	0.25	0.57	0.49	0.23	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	
200ha	(m3/sec)	0.43	0.19	0.14	0.18	0.29	0.00	0.11	0.00	0.48	0.83	0.55	0.34	0.76	0.65	0.30	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	
Low-flow reliability, 1 in 5 years: **300ha**	**(m3/sec)**	0.65	0.28	0.21	0.27	0.44	0.00	0.17	0.00	0.73	1.24	0.82	0.50	1.14	0.97	0.45	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	
400ha	(m3/sec)	0.86	0.37	0.28	0.37	0.58	0.00	0.22	0.00	0.97	1.66	1.10	0.67	1.52	1.30	0.61	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.25	
Low-flow reliability, 1 in 3 years: 500ha	(m3/sec)	1.08	0.46	0.35	0.46	0.73	0.00	0.28	0.00	1.21	2.07	1.37	0.84	1.90	1.62	0.76	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.31	
Low-flow reliability, 1 in 3 years: 550ha	(m3/sec)	1.19	0.51	0.39	0.50	0.80	0.00	0.30	0.00	1.33	2.28	1.51	0.93	2.09	1.78	0.83	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.34	
Low-flow reliability, 1 in 3 years: **600ha**	**(m3/sec)**	1.30	0.56	0.42	0.55	0.88	0.00	0.33	0.00	1.45	2.49	1.65	1.01	2.27	1.94	0.91	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.37	
650ha	(m3/sec)	1.40	0.60	0.46	0.59	0.95	0.00	0.36	0.00	1.58	2.69	1.78	1.09	2.46	2.11	0.98	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.41	
700ha	(m3/sec)	1.51	0.65	0.49	0.64	1.02	0.00	0.39	0.00	1.70	2.90	1.92	1.18	2.65	2.27	1.06	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.44	
800ha	(m3/sec)	1.73	0.74	0.56	0.73	1.17	0.00	0.44	0.00	1.94	3.31	2.19	1.35	3.03	2.59	1.21	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.50	
850ha	(m3/sec)	1.84	0.79	0.60	0.78	1.24	0.00	0.47	0.00	2.06	3.52	2.33	1.43	3.22	2.75	1.29	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.53	

Estimation of water requirement for land preparation

Peak requirement rate	Rainy season	Dry season
Sn:Water requirement rate(mm/day)		
Sn= (D+d x(N-1)) /N	**17.3 mm/day**	**15.6 mm/day**
D:Water requirement fot land preparation(mm)	300 mm	250 mm
d:Water requirement per day(mm)	7.5 mm	7.5 mm
N:Term of puddling(day)	30 days	30 days

Estimation of water layer replacement

Peak requirement rate	Rainy season
Wn:Water requirement rate(mm/day)	
Wn= (D+d x(N-1)) /N	**10.3 mm/day**
D:Water layer replacement(mm)	50 mm
d:Water requirement per day(mm)	7.5 mm
N:Term of water layer replacement(day)	15 day

(2) Present Cropping Pattern (Upland Only)

Pattern 8:

Upland 4-month			
Present situation			
Irrigation period:105-day			

Cropping pattern	season Rainy	Dry
1)Upstream: Main and Ramaskora and Ritabou 2ndary, upstream	60%	60%
2)Downstream: Ramskora and Ritabau 2ndary, downdstream	40%	40%

Initial water requirement(15days)

Upstream:	3.0mm/day
Downstream:	5.0mm/day

Irrigation efficiency (FAO criteria)

Application efficiency(Ea)	Ea=0.70
Branch canal efficiency(Eb)	Eb=0.80
Farm efficiency(Ef=Ea x Eb)	Ef=0.56
Conveyance efficiency(Ec)	Ec=0.65
Irrigation(Project) efficiency(Ep=Ef x Ec)	**Ep=0.364**

Item	Unit	January		February		March		April		May		June		July		August		September		October		November		December		Total/AV
Discharge of Bulobo river Maximum average discharge:		4.60		5.60		4.50		3.70		1.90		1.40		1.10		0.80		0.60		0.50		1.40		3.00		1.70
Average discharge:		**2.00**		**2.50**		**2.20**		**1.70**		**1.10**		**0.90**		**0.60**		**0.40**		**0.30**		**0.20**		**0.70**		**1.20**		**1.20**
Minimum average discharge:		0.40		0.80		0.70		0.60		0.40		0.30		0.20		0.10		0.10		0.10		0.20		0.30		0.50
Low-flow reliability, 1 in 2 years:		1.73		2.02		2.30		1.56		1.06		0.84		0.62		0.39		0.26		0.23		0.47		1.05		1.04
Low-flow reliability, 1 in 3 years:		1.33		1.67		1.68		1.42		0.99		0.75		0.49		0.31		0.20		0.19		0.30		0.84		0.85
Low-flow reliability, 1 in 5 years:	(m3/sec)	**0.94**		**1.37**		**1.37**		**1.30**		**0.95**		**0.73**		**0.46**		**0.28**		**0.18**		**0.16**		**0.29**		**0.71**		**0.90**
1. Cropping pattern, Crop coefficient (kc)																										
1)Upstream 60% 60%		0.98	0.82	0.35	0.00					0.40	0.54	0.82	0.96	0.98	0.82	0.35	0.00					0.40	0.54	0.82	0.96	
2)Downstream 40% 40%		0.82	0.96	0.98	0.82	0.35	0.00					0.40	0.54	0.82	0.96	0.98	0.82	0.35	0.00					0.40	0.54	
2. Consumptive use (ETcrop=kcxET$_0$)	(ET$_0$)	1.4	1.4	1.2	1.2	1.3	1.3	1.8	1.8	2.2	2.2	2.9	2.9	4.1	4.1	4.2	4.2	3.9	3.9	3.7	3.7	2.4	2.4	1.5	1.5	
1)Upstream 60% 60%		0.8	0.7	0.3						0.5	0.7	1.4	1.7	2.4	2.0	0.9						0.6	0.8	0.7	0.9	
3)Downstream 40% 40%		0.5	0.5	0.5	0.4	0.2						0.5	0.6	1.3	1.6	1.6	1.4	0.5						0.2	0.3	
Total	(mm/day)	1.3	1.2	0.7	0.4	0.2	0.0	0.0	0.0	0.5	0.7	1.9	2.3	3.8	3.6	2.5	1.4	0.5	0.0	0.0	0.0	0.6	0.8	1.0	1.2	
3. Initial water requirement																										
1)Upstream 60% 60%	3.0mm/day									1.8												1.8				
2)Downstream 40% 40%	5.0mm/day											2.0												2.0		
Total	(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	2.0	0.0	
4. Consumative use rate(2+3)	(mm/day)	1.3	1.2	0.7	0.4	0.2	0.0	0.0	0.0	2.3	0.7	3.9	2.3	3.8	3.6	2.5	1.4	0.5	0.0	0.0	0.0	2.4	0.8	3.0	1.2	
5. Total farm water requirement(=4)	(mm/day)	1.3	1.2	0.7	0.4	0.2	0.0	0.0	0.0	2.3	0.7	3.9	2.3	3.8	3.6	2.5	1.4	0.5	0.0	0.0	0.0	2.4	0.8	3.0	1.2	32.2
																						annual water requirement(mm)				**482**
6. Effective rainfall (source:WB F/S)																										
1) Agerage rainfall per month		380		362		312		120		100		43		12		12		13		78		208		305		1,945
2) Low-rainfall reliability, 1 in 5 years (reliability more than 80%)		106	117	106	92	76	81	13	13	12	13	0	0	0	0	0	0	0	0	10	11	45	45	95	152	987
3) Effective rainfall (80% of low-rainfall reliability, 1 in 5 years)		85	94	85	74	61	65	10	10	10	10	0	0	0	0	0	0	0	0	8	9	36	36	76	122	790
4) Effective rainfall per day	(mm/day)	5.7	6.2	5.7	4.9	4.1	4.3	0.7	0.7	0.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	2.4	2.4	5.1	8.1	
																						annual net water requirement(mm)				
7. Net water requirement(5-6)	(mm/day)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0	3.9	2.3	3.8	3.6	2.5	1.4	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	295
unit net water requirement	(lit/sec/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.45	0.27	0.43	0.42	0.29	0.16	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8. Unit diversion requirement at offtakes from 2ndary canal Farm efficiency: Ef=0.56	(lit/sec/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.80	0.47	0.78	0.74	0.52	0.28	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
9. Unit diversion requirement at intake Conveyance efficiency: Ec=0.65	(lit/sec/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.01	peak 1.24	0.73	1.19	1.14	0.80	0.44	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
10. Diversion requirement at intake Dry s. **100ha**	**(m3/sec)**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.12	0.07	0.12	0.11	0.08	0.04	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
150ha	(m3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.19	0.11	0.18	0.17	0.12	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Irrigation area: Rainy s. **250ha**	(m3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.31	0.18	0.30	0.29	0.20	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

(3) Cropping Pattern Proposed by World Bank F/S Report (Paddy + Upland)

Pattern 2:

Pattern 2
Paddy 105-day variety
1st crop starts on December
Irrigation Period:105-day

Cropping pattern

Cropping pattern	Rainy season	Dry season
Upstream: Main and Ramaskora and Ritabou 2ndary, upstream	30%	40%
Midstream: Ramskora and Ritabau 2ndary, midstream	30%	60%
Downstream: Ramskora and Ritabau 2ndary, downdstream	40%	0%

Percolation rate (water requirement rate measurement)

Up/Midstream:	2.5mm/day
Downstream:	2.5mm/day

Water requirement for land preparation (including ponding depth 50mm/month)

land preparation period:	1 month
beginning of rainy season cropping:	300mm
beginning of dry season cropping:	250mm

Water Layer Replacement(WLR):WB F/S report

50mm/15day

Irrigation efficiency (FAO criteria)

Application efficiency(Ea)	-
Branch canal efficiency(Eb)	-
Farm efficiency(Ef=Ea x Eb)	Ef=0.80
Conveyance efficiency(Ec)	Ec=0.725
Irrigation(Project) efficiency(Ep=Ef x Ec)	**Ep=0.580**

Item	January		February		March		April		May		June		July		August		September		October		November		December		Total/AV
Discharge of Bulobo river Maximum average discharge:	4.60		5.60		4.50		3.70		1.90		1.40		1.10		0.80		0.60		0.50		1.40		3.00		1.70
Average discharge:	**2.00**		**2.50**		**2.20**		**1.70**		**1.10**		**0.90**		**0.60**		**0.40**		**0.30**		**0.20**		**0.70**		**1.20**		**1.20**
Minimum average discharge:	0.40		0.80		0.70		0.60		0.40		0.30		0.20		0.10		0.10		0.10		0.20		0.30		0.50
Low-flow reliability, 1 in 2 years:	1.73		2.02		2.30		1.56		1.06		0.84		0.62		0.39		0.26		0.23		0.47		1.05		1.04
Low-flow reliability, 1 in 3 years:	1.33		1.67		1.68		1.42		0.99		0.75		0.49		0.31		0.20		0.19		0.30		0.84		0.85
Low-flow reliability, 1 in 5 years: (m3/sec)	**0.94**		**1.37**		**1.37**		**1.30**		**0.95**		**0.73**		**0.46**		**0.28**		**0.18**		**0.16**		**0.29**		**0.71**		**0.90**
1. Cropping pattern, Crop coefficient (kc)																									
1)Upstream 30% 40%	1.05	1.05	1.10	1.10	0.95	0.00	L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	0.40	0.54	0.96	0.96	0.98	0.82	0.35		L.P.	L.P.	
2)Midstream 30% 60%	1.05	1.05	1.10	1.10	0.95	0.00	L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	0.40	0.54	0.96	0.96	0.98	0.82	0.35		L.P.	L.P.	
3)Downstream 40% 0%	1.05	1.05	1.10	1.10	0.95	0.00	L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	0.40	0.54	0.96	0.96	0.98	0.82	0.35		L.P.	L.P.	
2. Evapo-transpiration (ET_0) (ET_0)	1.4	1.4	1.2	1.2	1.3	1.3	1.8	1.8	2.2	2.2	2.9	2.9	4.1	4.1	4.2	4.2	3.9	3.9	3.7	3.7	2.4	2.4	1.5	1.5	
Crop evapo-transpiration rate (ET_{crop}=kc x ET_0)																									
1)Upstream 30% 40%	0.4	0.4	0.4	0.4	0.4	0.0			0.9	0.9	1.3	1.3	1.6	0.0	0.7	0.9	1.5	1.5	1.5	1.2	0.3				
2)Midstream 30% 60%	0.4	0.4	0.4	0.4	0.4	0.0			1.4	1.4	1.9	1.9	2.3	0.0	1.0	1.4	2.2	2.2	2.2	1.8	0.5				
3)Downstream 40% 0%	0.6	0.6	0.5	0.5	0.5	0.0			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
Total (mm/day)	**1.5**	**1.5**	**1.3**	**1.3**	**1.2**	**0.0**	**0.0**	**0.0**	**2.3**	**2.3**	**3.2**	**3.2**	**3.9**	**0.0**	**1.7**	**2.3**	**3.7**	**3.7**	**3.6**	**3.0**	**0.8**	**0.0**	**0.0**	**0.0**	
3. Percolation rate																									
1)Upstream 30% 40% 2.5mm/day	0.8	0.8	0.8	0.8	0.8		1.0	1.0	1.0	1.0	1.0	1.0	1.0		1.0	1.0	1.0	1.0	1.0	1.0	1.0		0.8	0.8	
2)Midstream 30% 60% 2.5mm/day	0.8	0.8	0.8	0.8	0.8		1.5	1.5	1.5	1.5	1.5	1.5	1.5		1.5	1.5	1.5	1.5	1.5	1.5	1.5		0.8	0.8	
3)Downstream 40% 0% 2.5mm/day	1.0	1.0	1.0	1.0	1.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0		1.0	1.0	
Total (mm/day)	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**0.0**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**0.0**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**	**0.0**	**2.5**	**2.5**	
4. Water requirment rate (2+3) (mm/day)	**4.0**	**4.0**	**3.8**	**3.8**	**3.7**	**0.0**	**2.5**	**2.5**	**4.8**	**4.8**	**5.7**	**5.7**	**6.4**	**0.0**	**4.2**	**4.8**	**6.2**	**6.2**	**6.1**	**5.5**	**3.3**	**0.0**	**2.5**	**2.5**	
5. Net water requirement for land preparation (source:WB F/S)																									
1)Upstream 30% 40% Rainy season: 300mm/month							3.3	3.3															3.0	3.0	
2)Midstream 30% 60% Dry season: 250mm/month							5.0	5.0															3.0	3.0	
3)Downstream 40% 0%							0.0	0.0															4.0	4.0	
Total (mm/day)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**8.3**	**8.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**10.0**	**10.0**	
6. Water Layer Replacement: WLR																									
1)Upstream 30% 40% 50mm/15day		1.0		1.0						1.3		1.3													
2)Midstream 30% 60%		1.0		1.0						2.0		2.0													
3)Downstream 40% 0%		1.3		1.3						0.0		0.0													
Total (mm/day)	**0.0**	**3.3**	**0.0**	**3.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.3**	**0.0**	**3.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
7. Total farm water requirement (4+5+6) (mm/day)	**4.0**	**7.3**	**3.8**	**7.2**	**3.7**	**0.0**	**10.8**	**10.8**	**4.8**	**8.1**	**5.7**	**9.0**	**6.4**	**0.0**	**4.2**	**4.8**	**6.2**	**6.2**	**6.1**	**5.5**	**3.3**	**0.0**	**12.5**	**12.5**	**143.1**
annual water requirement(mm)																									**2,147**
8. Effective rainfall (source:WB F/S)																									
1) Agerage rainfall per month	380		362		312		120		100		43		12		12		13		78		208		305		1,945
2) Low-rainfall reliability, 1 in 5 years (reliability more than 80%)	106	117	106	92	76	81	13	13	12	13	0	0	0	0	0	0	0	0	10	11	45	45	95	152	987
3) Effective rainfall (80% of low-rainfall reliability, 1 in 5 years)	85	94	85	74	61	65	10	10	10	10	0	0	0	0	0	0	0	0	8	9	36	36	76	122	790
4) Effective rainfall per day (mm/day)	**5.7**	**6.2**	**5.7**	**4.9**	**4.1**	**4.3**	**0.7**	**0.7**	**0.6**	**0.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**0.6**	**2.4**	**2.4**	**5.1**	**8.1**	
annunal net water requirement(mm)																									
9. Net water requirement(7-8) (mm/day)	**0.0**	**1.1**	**0.0**	**2.2**	**0.0**	**0.0**	**10.1**	**10.1**	**4.2**	**7.5**	**5.7**	**9.0**	**6.4**	**0.0**	**4.2**	**4.8**	**6.2**	**6.2**	**5.6**	**4.9**	**0.9**	**0.0**	**7.4**	**4.4**	**1,516**
unit net water requirement (lit/sec/ha)	**0.00**	**0.12**	**0.00**	**0.26**	**0.00**	**0.00**	**1.17**	**1.17**	**0.48**	**0.86**	**0.66**	**1.04**	**0.74**	**0.00**	**0.48**	**0.55**	**0.72**	**0.72**	**0.65**	**0.57**	**0.11**	**0.00**	**0.86**	**0.51**	
10. Unit diversion requirement at offtakes from 2ndary canal Farm efficiency: Ef=0.80 (lit/sec/ha)	**0.00**	**0.15**	**0.00**	**0.33**	**0.00**	**0.00**	**1.47**	**1.47**	**0.60**	**1.08**	**0.82**	**1.31**	**0.93**	**0.00**	**0.60**	**0.69**	**0.90**	**0.90**	**0.81**	**0.72**	**0.14**	**0.00**	**1.08**	**0.64**	
11. Unit diversion requirement at intake Conveyance efficiency: Ec=0.725 (lit/sec/ha)	**0.00**	**0.21**	**0.00**	**0.45**	**0.00**	**0.00**	peak **2.02**	peak **2.02**	**0.83**	**1.49**	**1.14**	**1.80**	**1.28**	**0.00**	**0.83**	**0.95**	peak **1.25**	**1.25**	**1.12**	**0.99**	**0.19**	**0.00**	peak **1.48**	**0.88**	
12. Diversion requirement at intake 100ha (m3/sec)	0.00	0.02	0.00	0.04	0.00	0.00	0.20	0.20	0.08	0.15	0.11	0.18	0.13	0.00	0.08	0.10	0.12	0.12	0.11	0.10	0.02	0.00	0.15	0.09	
Irrigation area: **For upland** 150ha (m3/sec)	0.00	0.03	0.00	0.07	0.00	0.00	0.30	0.30	0.12	0.22	0.17	0.27	0.19	0.00	**0.13**	**0.14**	**0.19**	**0.19**	**0.17**	**0.15**	**0.03**	0.00	0.22	0.13	
200ha (m3/sec)	0.00	0.04	0.00	0.09	0.00	0.00	0.40	0.40	0.17	0.30	0.23	0.36	0.26	0.00	0.17	0.19	0.25	0.25	0.22	0.20	0.04	0.00	0.30	0.18	
250ha (m3/sec)	0.00	0.05	0.00	0.11	0.00	0.00	0.51	0.51	0.21	0.37	0.28	0.45	0.32	0.00	0.21	0.24	0.31	0.31	0.28	0.25	0.05	0.00	0.37	0.22	
300ha (m3/sec)	0.00	0.06	0.00	0.13	0.00	0.00	0.61	0.61	0.25	0.45	0.34	0.54	0.38	0.00	0.25	0.29	0.37	0.37	0.33	0.30	0.06	0.00	0.45	0.26	
For dry season **400ha** **(m3/sec)**	0.00	0.08	0.00	0.18	0.00	0.00	**0.81**	**0.81**	**0.33**	**0.59**	**0.45**	**0.72**	**0.51**	0.00	0.33	0.38	0.50	0.50	0.45	0.39	0.08	0.00	0.59	0.35	
For rainy season **500ha** **(m3/sec)**	**0.00**	**0.11**	**0.00**	**0.22**	**0.00**	0.00	1.01	1.01	0.42	0.74	0.57	0.90	0.64	0.00	0.42	0.48	0.62	0.62	0.56	0.49	0.09	0.00	**0.74**	**0.44**	
700ha (m3/sec)	0.00	0.15	0.00	0.31	0.00	0.00	1.42	1.42	0.58	1.04	0.79	1.26	0.89	0.00	0.58	0.67	0.87	0.87	0.78	0.69	0.13	0.00	1.04	0.61	
800ha (m3/sec)	0.00	0.17	0.00	0.36	0.00	0.00	1.62	1.62	0.67	1.19	0.91	1.44	1.02	0.00	0.67	0.76	1.00	1.00	0.89	0.79	0.15	0.00	1.19	0.70	
900ha (m3/sec)	0.00	0.19	0.00	0.40	0.00	0.00	1.82	1.82	0.75	1.34	1.02	1.62	1.15	0.00	0.75	0.86	1.12	1.12	1.00	0.89	0.17	0.00	1.34	0.79	

(4) Cropping Pattern Proposed by the BD (Paddy Only)

Pattern 6:

Paddy 105-day variety
2nd crop starts April(2)
Irrigation period:105 days

Cropping pattern	season Rainy	Dry
Upstream: Main and Ramaskora and Ritabou 2ndary, upstream	30%	60%
Midstream: Ramskora and Ritabau 2ndary, midstream	30%	40%
Downstream: Ramskora and Ritabau 2ndary, downdstream	40%	0%

Percolation rate (water requirement rate measurement)

Up/Midstream:	3.0mm/day
Downstream:	5.0mm/day

Water requirement for land preparation (including ponding depth 50mm/month)

land preparation period:	1 month
beginning of rainy season cropping:	300mm
beginning of dry season cropping:	250mm
Water Layer Replacement(WLR):WB F/S report	
50mm/15day	

Irrigation efficiency (FAO criteria)

Application efficiency(Ea)	Ea=0.80
Branch canal efficiency(Eb)	Eb=0.80
Farm efficiency(Ef=Ea x Eb)	Ef=0.64
Conveyance efficiency(Ec)	Ec=0.85
Irrigation(Project) efficiency(Ep=Ef x Ec)	Ep=0.544

Item	Unit	January		February		March		April		May		June		July		August		September		October		November		December		Total/AV
Discharge of Bulobo river Maximum average discharge:		4.60		5.60		4.50		3.70		1.90		1.40		1.10		0.80		0.60		0.50		1.40		3.00		1.70
Average discharge:		**2.00**		**2.50**		**2.20**		**1.70**		**1.10**		**0.90**		**0.60**		**0.40**		**0.30**		**0.20**		**0.70**		**1.20**		**1.20**
Minimum average discharge:		0.40		0.80		0.70		0.60		0.40		0.30		0.20		0.10		0.10		0.10		0.20		0.30		0.50
Low-flow reliability, 1 in 2 years:		1.73		2.02		2.30		1.56		1.06		0.84		0.62		0.39		0.26		0.23		0.47		1.05		1.04
Low-flow reliability, 1 in 3 years:		1.33		1.67		1.68		1.42		0.99		0.75		0.49		0.31		0.20		0.19		0.30		0.84		0.85
Low-flow reliability, 1 in 5 years:	(m3/sec)	**0.94**		**1.37**		**1.37**		**1.30**		**0.95**		**0.73**		**0.46**		**0.28**		**0.18**		**0.16**		**0.29**		**0.71**		**0.90**
1. Cropping pattern, Crop coefficient (kc)																										
1)Upstream 30% 60%		1.05	1.05	1.10	1.10	0.95	0.00	-	L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	-							L.P.	L.P.	
2)Midstream 30% 40%		L.P	1.05	1.05	1.10	1.10	0.95	0.00	-	L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	-							L.P.	
3)Downstream 40% 0%			L.P	L.P	1.05	1.05	1.10	1.10	0.95	0.00	L.P.	L.P.	1.05	1.05	1.10	1.10	0.95	0.00	-							
2. Evapo-transpiration (ET_0)	(ET_0)	**1.4**	**1.4**	**1.2**	**1.2**	**1.3**	**1.3**	**1.8**	**1.8**	**2.2**	**2.2**	**2.9**	**2.9**	**4.1**	**4.1**	**4.2**	**4.2**	**3.9**	**3.9**	**3.7**	**3.7**	**2.4**	**2.4**	**1.5**	**1.5**	
Crop evapo-transpiration rate (ETcrop=kc x ET_0)																										
1)Upstream 30% 60%		0.4	0.4	0.4	0.4	0.4	0.0				1.4	1.8	1.9	2.7	2.3											
2)Midstream 30% 40%			0.4	0.4	0.4	0.4	0.4	0.0				1.2	1.2	1.8	1.8	1.6										
3)Downstream 40% 0%					0.5	0.5	0.6	0.8	0.7	0.0			0.0	0.0	0.0	0.0	0.0									
Total	(mm/day)	**0.4**	**0.9**	**0.8**	**1.3**	**1.3**	**0.9**	**0.8**	**0.7**	**0.0**	**1.4**	**3.0**	**3.1**	**4.5**	**4.1**	**1.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
3. Percolation rate																										
1)Upstream 30% 60% 3.0mm/day		0.9	0.9	0.9	0.9	0.9			1.8	1.8	1.8	1.8	1.8	1.8	1.8									0.9	0.9	
2)Midstream 30% 40% 3.0mm/day		0.9	0.9	0.9	0.9	0.9	0.9			1.2	1.2	1.2	1.2	1.2	1.2	1.2									0.9	
3)Downstream 40% 0% 5.0mm/day			2.0	2.0	2.0	2.0	2.0	2.0	2.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0									
Total	(mm/day)	**1.8**	**3.8**	**3.8**	**3.8**	**3.8**	**2.9**	**2.0**	**3.8**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**1.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.9**	**1.8**	
4. Water requirment rate (2+3)	(mm/day)	**2.2**	**4.7**	**4.6**	**5.1**	**5.1**	**3.8**	**2.8**	**4.5**	**3.0**	**4.4**	**6.0**	**6.1**	**7.5**	**7.1**	**2.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.9**	**1.8**	
5. Net water requirement for land preparation																										
1)Upstream 30% 60% Rainy season: 17.3mm/day									7.6	7.6														4.3	4.3	
2)Midstream 30% 40% Dry season: 15.6mm/day		4.3								5.0	5.0														4.3	
3)Downstream 40% 0%			4.9	4.9							0.0	0.0														
Total	(mm/day)	**4.3**	**4.9**	**4.9**					**7.6**	**12.6**	**5.0**	**0.0**											**0.0**	**4.3**	**8.6**	
6. Water Layer Replacement: WLR																										
1)Upstream 30% 60% 10.3mm/day				2.2									4.4													
2)Midstream 30% 40%					2.2									2.9												
3)Downstream 40% 0%							2.1								0.0											
Total	(mm/day)		**0.0**	**2.2**	**2.2**	**0.0**	**2.1**						**4.4**	**2.9**	**0.0**											
7. Total farm water requirement (4+5+6)	(mm/day)	**6.5**	**9.6**	**11.7**	**7.3**	**5.1**	**6.0**	**2.8**	**12.0**	**15.6**	**9.4**	**6.0**	**10.5**	**10.4**	**7.1**	**2.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.2**	**10.4**	**138.5**
																						annual water requirement(mm)				**2,078**
8. Effective rainfall (source:WB F/S)																										
1) Agerage rainfall per month		380		362		312		120		100		43		12		12		13		78		208		305		1,945
2) Low-rainfall reliability, 1 in 5 years (reliability more than 80%)		106	117	106	92	76	81	13	13	12	13	0	0	0	0	0	0	0	0	10	11	45	45	95	152	987
3) Effective rainfall (80% of low-rainfall reliability, 1 in 5 years)		85	94	85	74	61	65	10	10	10	10	0	0	0	0	0	0	0	0	8	9	36	36	76	122	790
4) Effective rainfall per day	(mm/day)	**5.7**	**6.2**	**5.7**	**4.9**	**4.1**	**4.3**	**0.7**	**0.7**	**0.6**	**0.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**0.6**	**2.4**	**2.4**	**5.1**	**8.1**	
																						annunal net water requirement(mm)				
9. Net water requirement(7-8)	(mm/day)	**0.9**	**3.3**	**6.0**	**2.4**	**1.1**	**1.7**	**2.1**	**11.3**	**14.9**	**8.7**	**6.0**	**10.5**	**10.4**	**7.1**	**2.8**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**2.2**	**1,377**
unit net water requirement	(lit/sec/ha)	**0.10**	**0.39**	**0.70**	**0.28**	**0.13**	**0.19**	**0.24**	**1.31**	**1.73**	**1.01**	**0.70**	**1.22**	**1.21**	**0.83**	**0.32**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.26**	
10. Unit diversion requirement at offtakes from 2ndary canal Farm efficiency: Ef=0.64	(lit/sec/ha)	**0.16**	**0.60**	**1.09**	**0.43**	**0.20**	**0.30**	**0.38**	**2.05**	**2.70**	**1.58**	**1.09**	**1.90**	**1.89**	**1.29**	**0.51**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.41**	
11. Diversion requirement at intake Conveyance efficiency: Ec=0.85	(lit/sec/ha)	**0.18**	**0.71**	peak **1.29**	**0.51**	**0.23**	**0.35**	**0.45**	**2.41**	peak **3.18**	**1.86**	**1.29**	**2.24**	**2.22**	**1.52**	**0.59**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.48**	
								Rainy seasc	**0.54**																	
								Dry seasoı	**1.87**																	
12. Diversion requirement at intake 100ha	(m3/sec)	0.02	0.07	0.13	0.05	0.02	0.04	0.04	0.19	0.32	0.19	0.13	0.22	0.22	0.15	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	
Dry season **150ha**	**(m3/sec)**	0.03	0.11	0.19	0.08	0.03	0.05	0.07	0.28	0.48	0.28	0.19	0.34	0.33	0.23	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	
200ha	**(m3/sec)**	0.04	0.14	0.26	0.10	0.05	0.07	0.09	0.37	0.64	0.37	0.26	0.45	0.44	0.30	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	
Irrigation area: **250ha**	**(m3/sec)**	0.05	0.18	0.32	0.13	0.06	0.09	0.11	0.47	0.79	0.46	0.32	0.56	0.56	0.38	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.12	
300ha	**(m3/sec)**	0.06	0.21	0.39	0.15	0.07	0.11	0.13	0.56	0.95	0.56	0.39	0.67	0.67	0.46	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.14	
600ha	(m3/sec)	0.11	0.43	0.77	0.31	0.14	0.21	0.27	0.32	1.91	1.11	0.77	1.34	1.33	0.91	0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.29	
700ha	(m3/sec)	0.13	0.50	0.90	0.36	0.16	0.25	0.31	0.38	2.23	1.30	0.90	1.57	1.56	1.06	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.33	
750ha	(m3/sec)	0.14	0.53	0.97	0.38	0.17	0.26	0.33	0.40	2.38	1.39	0.96	1.68	1.67	1.14	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.36	
Rainy season **800ha**	**(m3/sec)**	0.15	0.57	1.03	0.41	0.19	0.28	0.36	0.43	2.54	1.49	1.03	1.79	1.78	1.22	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.38	
850ha	**(m3/sec)**	0.16	0.60	1.10	0.43	0.20	0.30	0.38	0.46	2.70	1.58	1.09	1.90	1.89	1.29	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.41	
900ha	**(m3/sec)**	0.17	0.64	1.16	0.46	0.21	0.32	0.40	0.48	2.86	1.67	1.16	2.02	2.00	1.37	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.43	
950ha	**(m3/sec)**	0.17	0.68	1.23	0.48	0.22	0.33	0.42	0.51	3.02	1.76	1.22	2.13	2.11	1.44	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.45	
1,000ha	**(m3/sec)**	0.18	0.71	1.29	0.51	0.23	0.35	0.45	0.54	3.18	1.86	1.29	2.24	2.22	1.52	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.48	
1,050ha	(m3/sec)	0.19	0.75	1.35	0.53	0.24	0.37	0.47	0.57	3.34	1.95	1.35	2.35	2.33	1.60	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.50	
13. Water taken by Water service facilitiy **15lit/sec**	(m3/sec)	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	
14. Total(1,050+200):	(m3/sec)	**0.21**	**0.76**	**1.37**	**0.55**	**0.26**	**0.38**	**0.48**	**0.86**	**0.49**	**0.29**	**0.21**	**0.35**	**0.35**	**0.24**	**0.10**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.02**	**0.04**	**0.52**	

Estimation of water requirement for land preparation

Peak requirement per day	Rainy season	Dry season
Sn:Water requirement rate(mm/day) Sn= (D+d x(N-1)) /N	**17.3 mm/day**	**15.6 mm/day**
D:Water requirement for land preparation(mm)	300 mm	250 mm
d:Water requirement per day(mm)	7.5 mm	7.5 mm
N:Term of puddling(day)	30 days	30 days

Estimation of water layer replacement

Peak requirement rate	Rainy season
Wn:Water requirement per day(mm/day) Wn= (D+d x(N-1)) /N	**10.3 mm/day**
D:Water layer replacement(mm)	50 mm
d:Water requirement per day(mm)	7.5 mm
N:Term of water layer replacement(day)	15 day

(5) Cropping Pattern proposed by the BD（Upland only）

Pattern 8:

Upland 4-month
2nd crop starts on November
Irrigation period:105-day

Cropping pattern
1)Upstream: Main, Ramaskora & Ritabou 2ndary, upstream
2)Downstream: Ramskora & Ritabau 2ndary, downdstream

season	Rainy	Dry
	60%	60%
	40%	40%

Initial water requirement(15days)

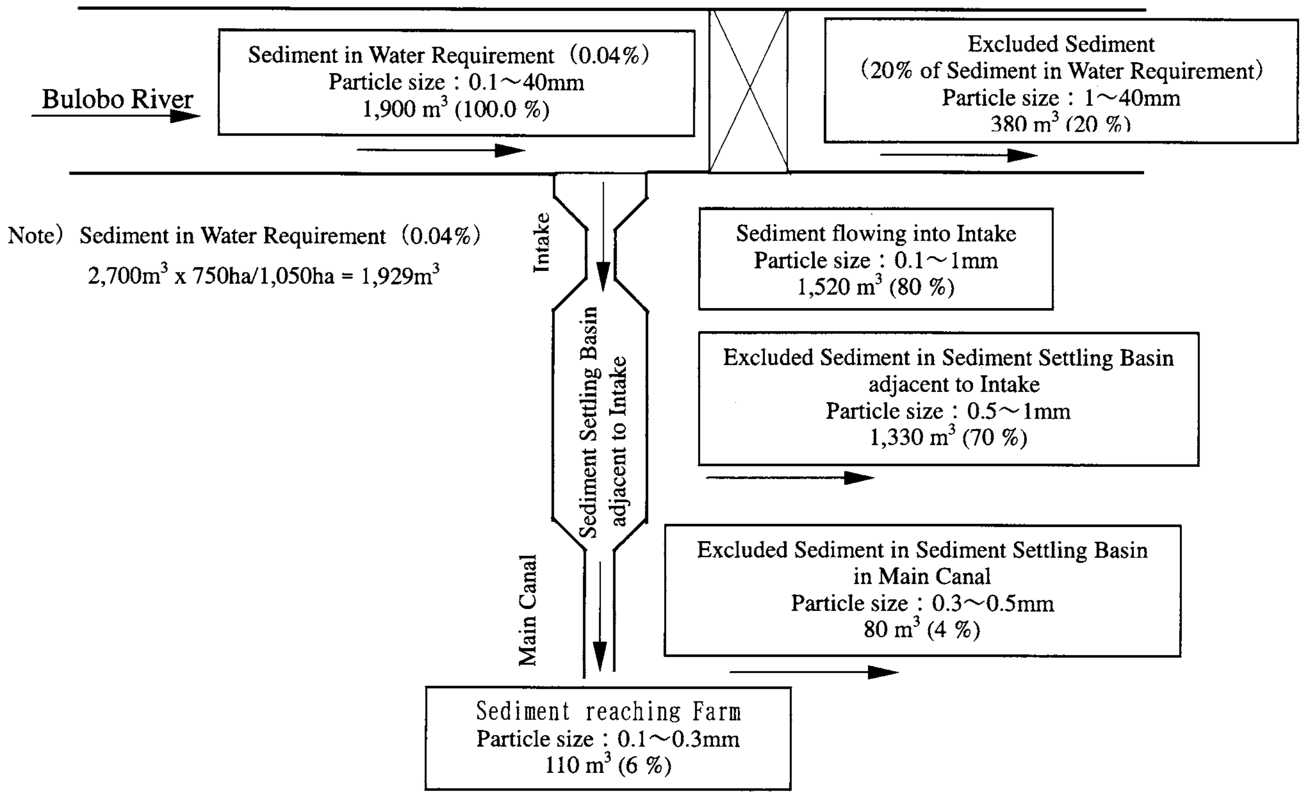
Upstream:	3.0mm/day
Downstream:	3.0mm/day

Irrigation efficiency（FAO criteria）

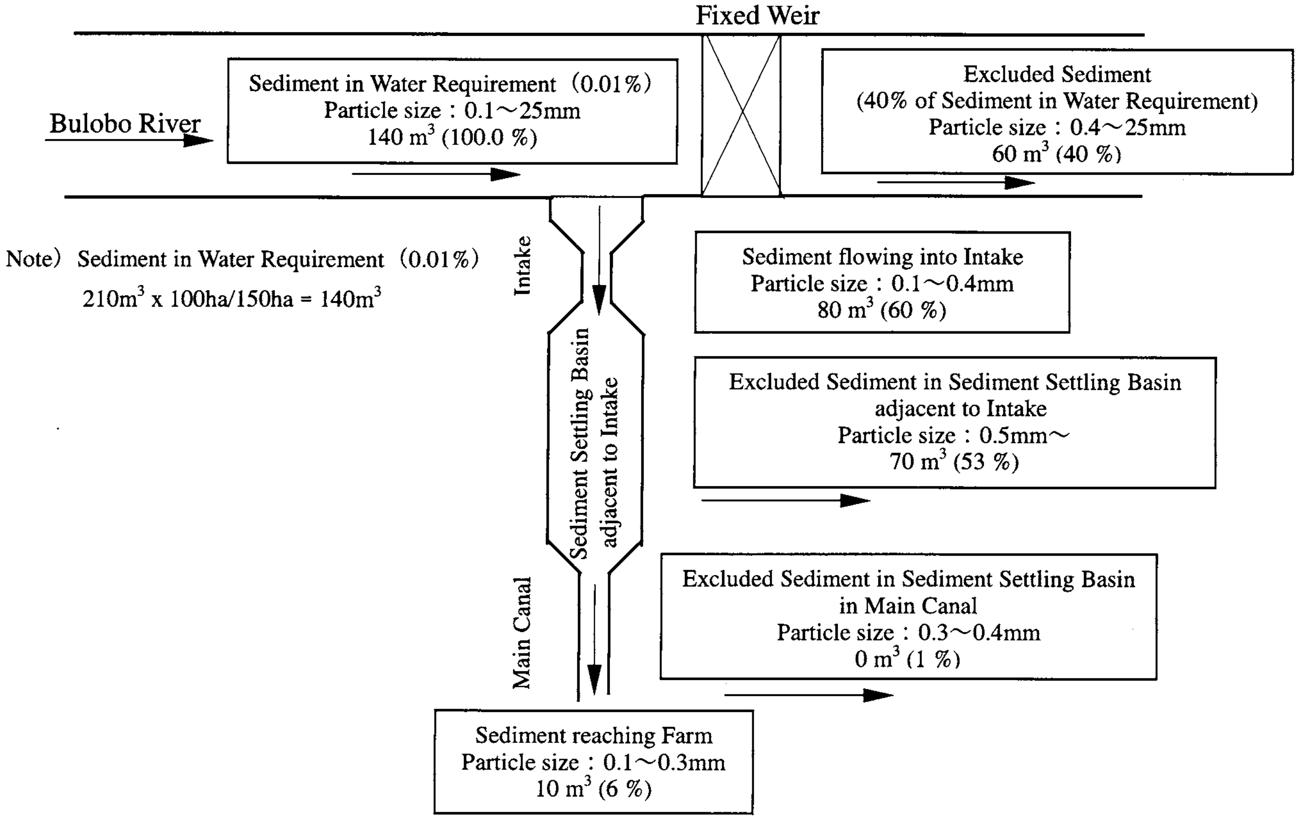
Application efficiency(Ea)	Ea=0.70
Branch canal efficiency(Eb)	Eb=0.80
Farm efficiency(Ef=Ea x Eb)	Ef=0.56
Conveyance efficiency(Ec)	Ec=0.85
Irrigation(Project) efficiency(Ep=Ef x Ec)	**Ep=0.476**

	January		February		March		April		May		June		July		August		September		October		November		December		Total/AV
Discharge of Bulobo river Maximum average discharge:	4.60		5.60		4.50		3.70		1.90		1.40		1.10		0.80		0.60		0.50		1.40		3.00		1.70
Average discharge:	**2.00**		**2.50**		**2.20**		**1.70**		**1.10**		**0.90**		**0.60**		**0.40**		**0.30**		**0.20**		**0.70**		**1.20**		**1.20**
Minimum average discharge:	0.40		0.80		0.70		0.60		0.40		0.30		0.20		0.10		0.10		0.10		0.20		0.30		0.50
Low-flow reliability, 1 in 2 years:	1.73		2.02		2.30		1.56		1.06		0.84		0.62		0.39		0.26		0.23		0.47		1.05		1.04
Low-flow reliability, 1 in 3 years:	1.33		1.67		1.68		1.42		0.99		0.75		0.49		0.31		0.20		0.19		0.30		0.84		0.85
Low-flow reliability, 1 in 5 years: (m3/sec)	**0.94**		**1.37**		**1.37**		**1.30**		**0.95**		**0.73**		**0.46**		**0.28**		**0.18**		**0.16**		**0.29**		**0.71**		**0.90**
1. Cropping pattern, Crop coefficient (kc)																									
1)Upstream 60% 60%	0.98	0.82	0.35	0.00		0.00	0.40	0.54	0.82	0.96	0.98	0.82	0.35	0.00							0.40	0.54	0.82	0.96	
2)Midstream 40% 40%	0.96	0.98	0.82	0.35	0.00		0.00	0.40	0.54	0.82	0.96	0.98	0.82	0.35	0.00							0.40	0.54	0.82	
2. Consumptive use (ETcrop=kcxET$_0$) (ET$_0$)	1.4	1.4	1.2	1.2	1.3	1.3	1.8	1.8	2.2	2.2	2.9	2.9	4.1	4.1	4.2	4.2	3.9	3.9	3.7	3.7	2.4	2.4	1.5	1.5	
1)Upstream 60% 60%	0.8	0.7	0.3				0.4	0.6	1.1	1.3	1.7	1.4	0.9	0.0											
2)Midstream 40% 40%	0.5	0.5	0.4	0.2				0.3	0.5	0.7	1.1	1.1	1.3	0.6	0.0										
Total (mm/day)	**1.4**	**1.2**	**0.6**	**0.2**	**0.0**	**0.0**	**0.4**	**0.9**	**1.6**	**2.0**	**2.8**	**2.6**	**2.2**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	
3. Initial water requirement																									
1)Upstream 60% 60% 3.0mm/day							1.8														1.8				
2)Midstream 40% 40% 3.0mm/day								1.2														1.2			
Total (mm/day)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**1.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**1.2**	**0.0**	**0.0**	
4. Consumative use rate(2+3) (mm/day)	**1.4**	**1.2**	**0.6**	**0.2**	**0.0**	**0.0**	**2.2**	**2.1**	**1.6**	**2.0**	**2.8**	**2.6**	**2.2**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.8**	**1.2**	**0.0**	**0.0**	
5. Total farm water requirement(=4) (mm/day)	1.4	1.2	0.6	0.2	0.0	0.0	2.2	2.1	1.6	2.0	2.8	2.6	2.2	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.2	0.0	0.0	**22.4**
																					annual water requirement(mm)				**336**
6. Effective rainfall (source:WB F/S)																									
1) Agerage rainfall per month	380		362		312		120		100		43		12		12		13		78		208		305		1,945
2) Low-rainfall reliability, 1 in 5 years (reliability more than 80%)	106	117	106	92	76	81	13	13	12	13	0	0	0	0	0	0	0	0	10	11	45	45	95	152	987
3) Effective rainfall (80% of low-rainfall reliability, 1 in 5 years)	85	94	85	74	61	65	10	10	10	10	0	0	0	0	0	0	0	0	8	9	36	36	76	122	790
4) Effective rainfall per day (mm/day)	**5.7**	**6.2**	**5.7**	**4.9**	**4.1**	**4.3**	**0.7**	**0.7**	**0.6**	**0.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.5**	**0.6**	**2.4**	**2.4**	**5.1**	**8.1**	
																					annual net water requirement(mm)				
7. Net water requirement(5-6) (mm/day)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.5**	**1.4**	**0.9**	**1.3**	**2.8**	**2.6**	**2.2**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**199**
unit net water requirement (lit/sec/ha)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.18**	**0.16**	**0.11**	**0.15**	**0.33**	**0.30**	**0.26**	**0.07**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	
8. Unit diversion requirement at offtakes from 2ndary canal Farm efficiency: Ef=0.56 (lit/sec/ha)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.32**	**0.28**	**0.19**	**0.27**	**0.58**	**0.53**	**0.46**	**0.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	
9. Unit diversion requirement at intake Conveyance efficiency: Ec=0.85 (lit/sec/ha)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.37**	**0.34**	**0.22**	**0.31**	peak **0.69**	**0.62**	**0.54**	**0.14**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	
10. Diersion requirement at intake Irrigation area: 100ha (m3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.03	0.02	0.03	0.07	0.06	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
150ha (m3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.05	0.03	0.05	0.10	0.09	0.08	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
200ha (m3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.07	0.04	0.06	0.14	0.12	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
250ha (m3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.08	0.06	0.08	0.17	0.16	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
300ha (m3/sec)	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.10	0.07	0.09	0.21	0.19	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

(1) Fixed Weir Type



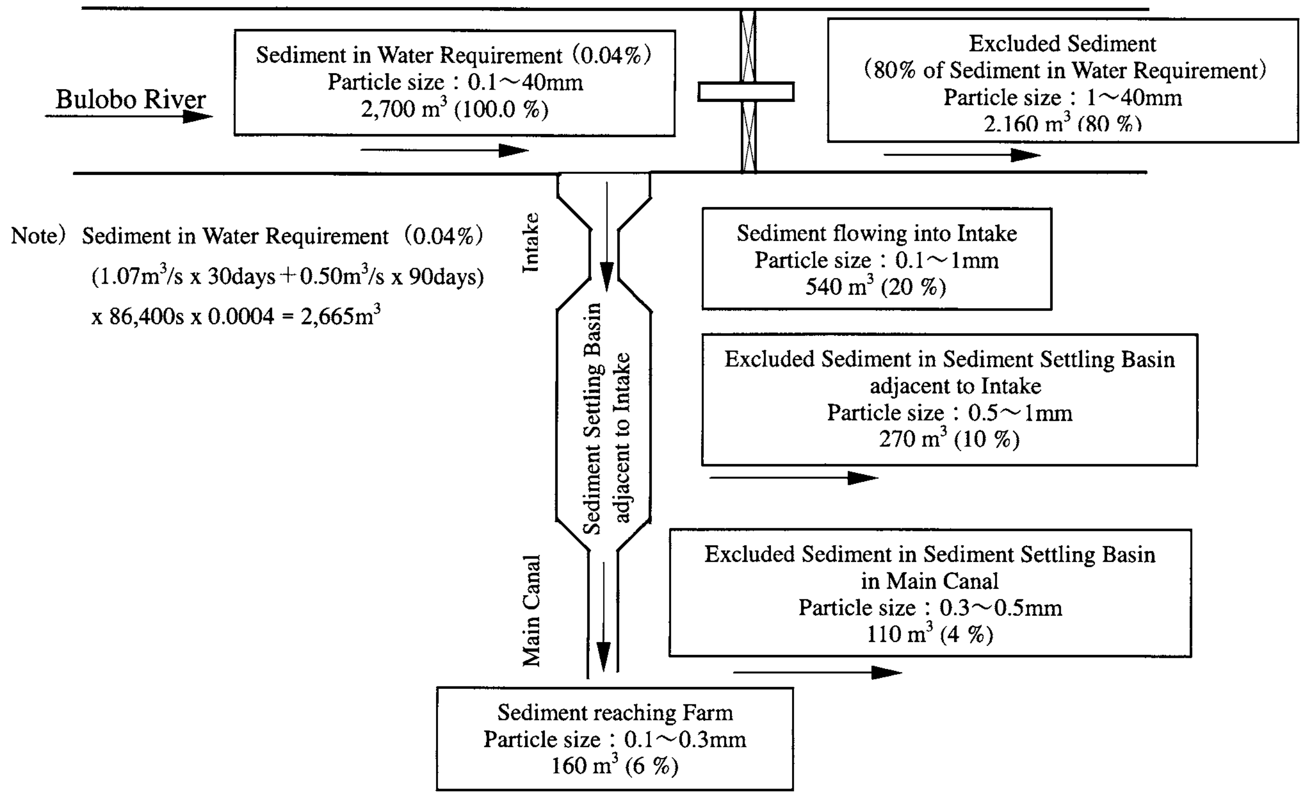
Sediment Control Measure in Rainy Season



Sediment Control Measure in Dry Season

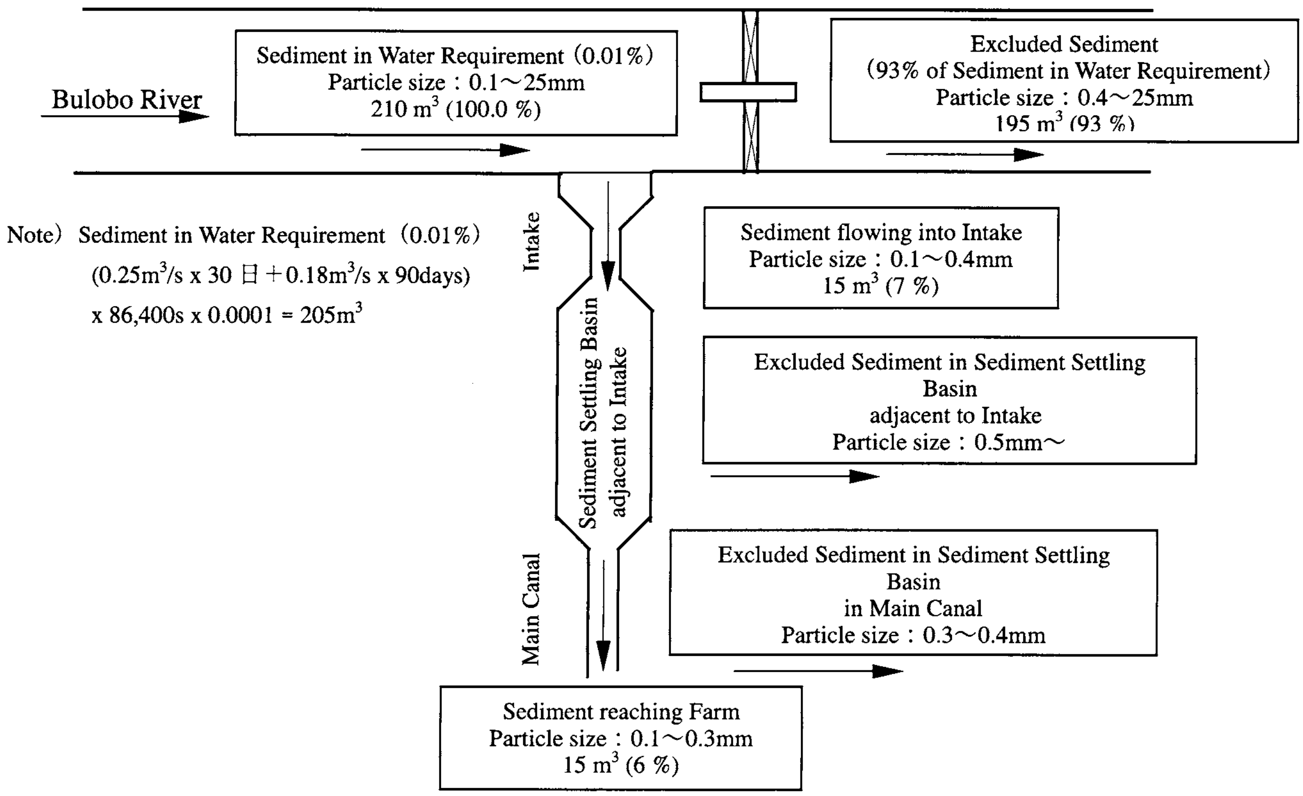
Figure A 5-8.1 Sediment Control by Proposed Fixed Weir

(2) Gate Type Scouring Sluice



Sediment Control Measure in Rainy Season

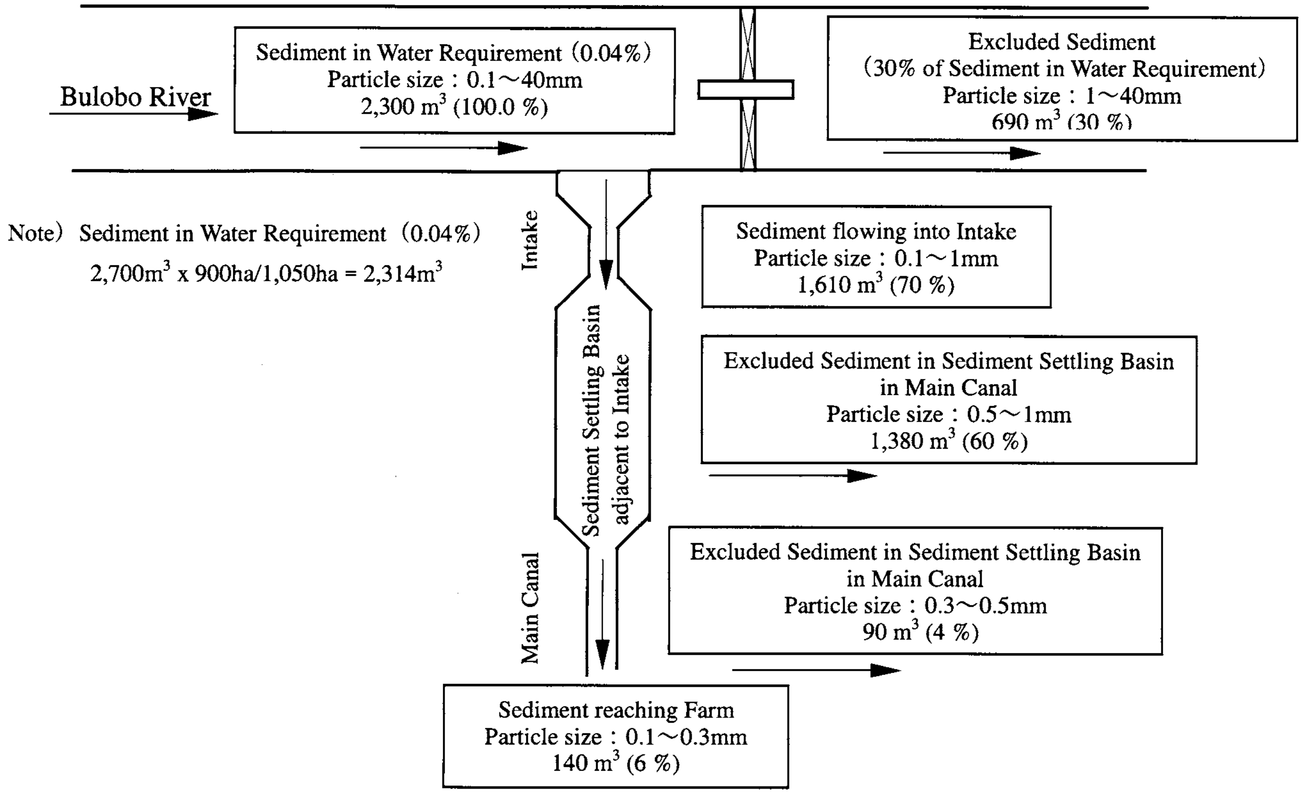
Gate Type Scouring Sluice



Sediment Control Measure in Dry Season

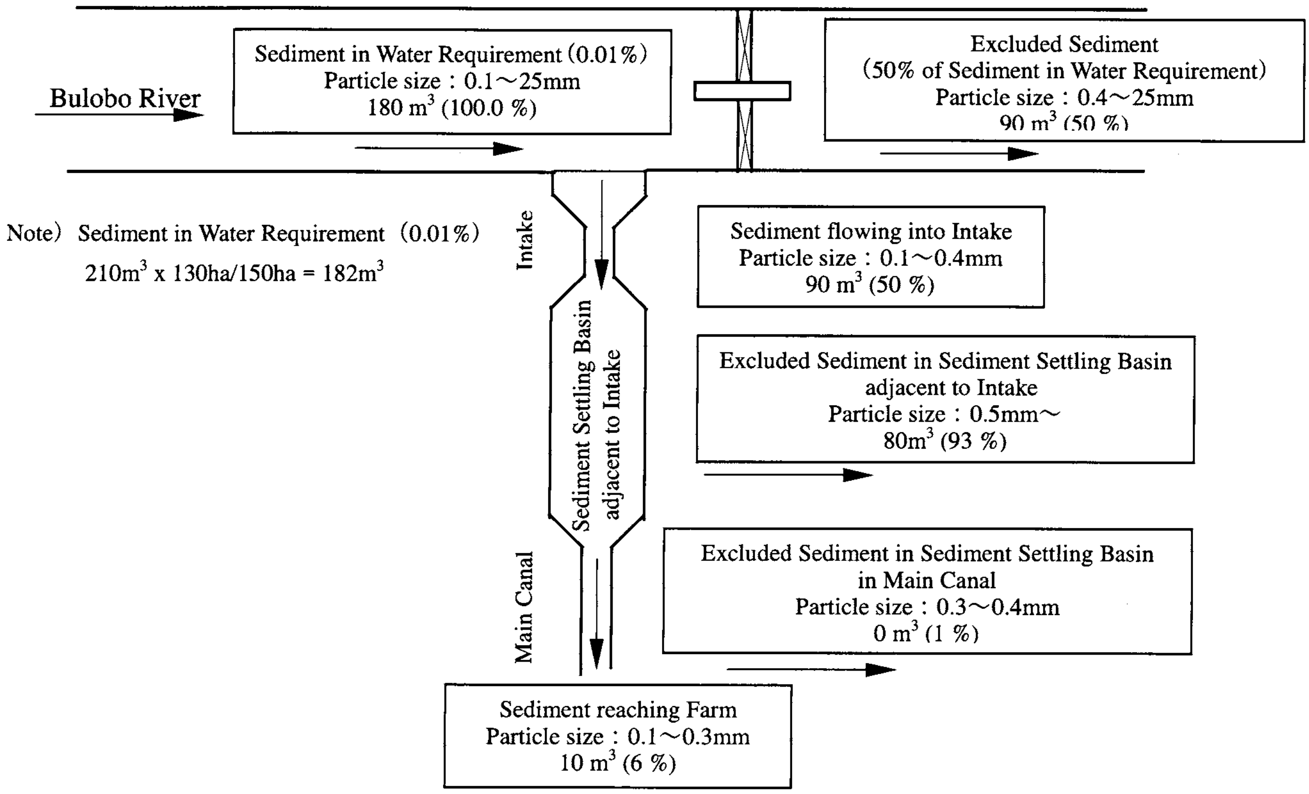
Figure A 5-8.2 Sediment Control by Proposed Gate Type Scouring Sluice

(3) Stop Log Type Scouring Sluice



Sediment Control Measure in Rainy Season

Stop Log Type Scouring Sluice

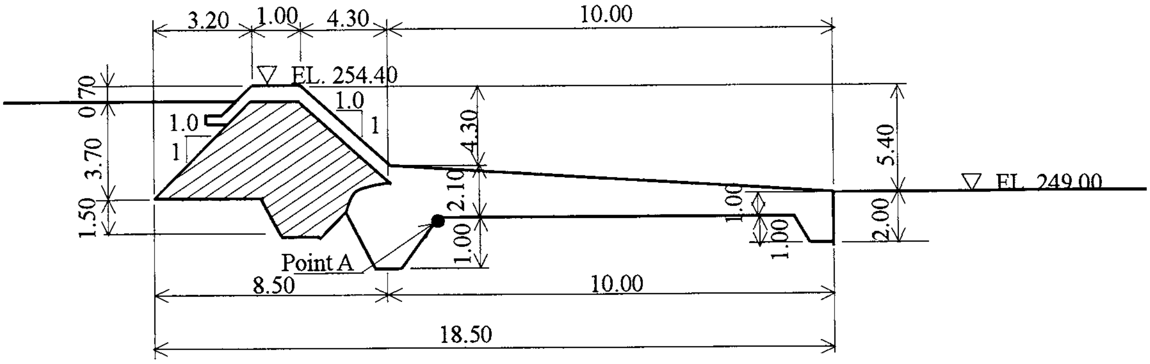


Sediment Control Measure in Dry Season

Figure A 5-8.3 Sediment Control by Proposed Stop Log Type Scouring Sluice

5-9. 1 Design of Fixed Weir

Longitudinal cross section of designed headworks



(1) Downstream apron of fixed weir

① Length of downstream apron

The fixed weir has an apron on the downstream side to avoid possible scouring by water flow over the weir body. The length of the downstream apron is determined as follows (See Headwork Design Standard of MAFF, page 207);

The length of the downstream apron is obtained using the Bligh's formula.

$$l_1 = 0.6 \times C\sqrt{D_1} = 0.6 \times 4 \times \sqrt{5.40} = 5.57 \text{ m}$$

Where;

l_1 = Length of the downstream apron (m)

D_1 = Elevation difference between the weir crown and the top at the apron downstream end (i.e. D_1 = EL 254.40 m − EL 249.00 m = 5.40 m)

C = Bligh's coefficient, which is 4 for boulders, gravel and sand

In conclusion, the length of the downstream apron is determined to be 10.0 m as a combination of creep length (discussed in the following section), downstream apron length of the scouring sluice (discussed in Section 2-4.2 (3)) and 5.57 m obtained above.

② Method of creep length examination

It is essential to secure a creep length along with ground-contact surface of the weir or back face of bank protection retaining walls for prevention of piping. The creep length to prevent piping is calculated using two methods: Bligh's and Lane's methods. After comparing two values to each other, the larger one is adopted as the minimum length of creep length (See Headwork Design Standard of MAFF, page 192).

Assuming the downstream one is zero, to be safer, the maximum water level difference between up- and downstream sides is calculated. Weep holes are installed in the cutoff wall at the downstream end of the downstream apron, to reduce uplift pressure. Therefore, we do not consider the width of cutoff wall as a part of the creep length.

③ Examination of creep length

i) Bligh's method

$S \geq C \times \Delta H = 4 \times 5.40 = 21.60 \text{ m} \leq 27.20 \text{ m}$

where

S = Creep length along with ground-contact surface of the weir (m)

(i.e. $S = 3.70 + 1.50 \times 2 + 1.00 \times 2 + 18.50 = 27.20$ m)

C = Bligh's coefficient, which is 4 for boulders, gravel and sand

ΔH = the maximum water level difference between up- and downstream sides

= 5.40 m

ii) Lane's method

$L \geq C' \times \Delta H = 2.5 \times 5.40 = 13.50 \text{ m} \leq 14.87 \text{ m}$

where

L = Weighted creep length (m), $L = \sum l_V + (1/3)\sum l_h$

$L = (3.70+1.50\times2+1.00\times2) + 1/3 \times 18.50 = 14.87$ m

C' = Lane's weighted coefficient, which is 2.5 for boulders, gravel and stones

ΔH = the maximum water level difference between up- and downstream sides

= 5.40 m

As a result, the downstream apron length of 10.0 m satisfies both inequalities above and is inferred to be safe.

④ Thickness of downstream apron

The thickness of the downstream apron is obtained from the following inequality concerning the uplifting pressure balance (See Headwork Design Standard of MAFF, page 207).

$$t \geq \frac{4}{3} \times \frac{\Delta H - H_f}{\gamma - 1}$$

where

t = Apron thickness at a point of interest (m)

ΔH = the maximum water level difference between up- and downstream sides

= 5.40 m

H_f = Head loss of percolating water to the point of interest

γ = Specific gravity of the material of weir and apron, $\gamma = 2.35$ tf/m^3

$\frac{4}{3}$ = Safety factor

- Overall creep length

  $L_X = 3.70 + 1.50 \times 2 + 1.00 \times 2 + 18.50 = 27.20$ m

- Creep length to Point A

$L_A = 3.70 + 1.50 \times 2 + 1.00 \times 2 + 8.50 = 17.20$ m

- Head loss of percolating water to Point A

  $H_f = (L_A/L_x) \times \Delta H = (17.20/27.20) \times 5.40 = 3.41$ m

- Apron thickness

$$t \geq \frac{4}{3} \times \frac{\Delta H - H_f}{\gamma - 1} = \frac{4}{3} \times \frac{5.40 - 3.41}{2.35 - 1} = 1.97 \text{ m}$$

Consequently, the apron thickness at Point A, t, is determined to be 2.10 m.

(2) Length of riverbed protection of fixed weir

① Length of riverbed protection

In addition to the downstream apron, riverbed protection is implemented to avoid possible scouring by water flow over the fixed weir. The length of riverbed protection is determined as follows (See Headwork Design Standard of MAFF, page 259);

The length of riverbed protection is obtained using the Bligh's formula.

$$L = L_B - l_a$$

$$L_B = 0.67 \times C\sqrt{H_a \times q} \times \text{f} = 0.67 \times 4 \times \sqrt{5.40 \times 11.22} \times 1.0 = 20.86 \text{ m}$$

Where;

L = Length of riverbed protection

L_B = Total of apron length l_a and riverbed protection length L

H_a = Elevation difference between the weir crown and downstream-side water level during drought period

H_a = EL 254.40 m − WL 249.00 m = 5.40 m

q = Design flood discharge per unit width, q = 11.22 m^3/sec/m

f = Safety factor of fixed weir, f = 1.0

L = 20.86 − 10.00 = 10.86 m

Thus, the length of riverbed protection is determined to be 12.0 m, that is 3 m × 3 rows.

② Riverbed Protection Block

Riverbed protection blocks must be stable against water flow. The approximate weight of a riverbed protection block is determined as follows (See Headwork Design Standard of MAFF, page 259):

$$W \geq 3.77 \times A \times \frac{V^2}{2g} = 3.77 \times 1.35 \times \frac{5.25^2}{2 \times 9.8} = 7.16 \text{ tf}$$

Where;

W = Weight of a riverbed protection block (tf)

A = Area of a block exposed perpendicular to water flow (m^2)

$A = 0.50 \times 2.70 = 1.35$ m^2

V = Velocity of water when it hits blocks, $V = 5.25$ m/sec

g = acceleration of gravity = 9.8 m/sec^2

Thus, riverbed protection blocks are crossing type and made of in-place concrete. The size of a block is 2.70 m in width, 2.70 m in length and1.00 m in height, and the weight is 8.75 of each.

5-9. 2 Design of Scouring Sluice

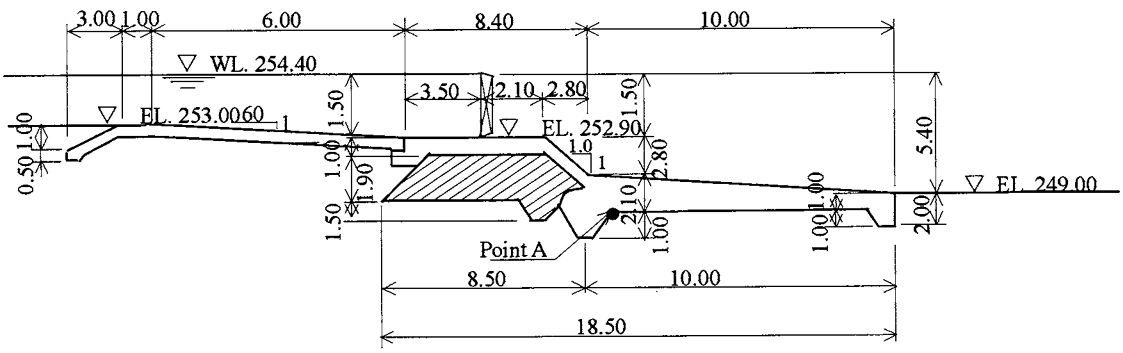
(1) Width of scouring sluice

The width of scouring sluice is determined so that the inside water velocity is approximately 0.4 m/sec for water intake at the normal flow rate during the wet period (approximately 2.0 m^3/sec). Assuming the sedimentation depth is 0.5 m, the effective depth inside the scouring depth is 0.9 m.

Width of scouring sluice, B = 2.0 (m^3/sec) × 0.4 (m/sec) × 0.9 (m) = 5.6 (m) Therefore, the scouring sluice is composed of two sets of sluice gates. The gate size is 3 meter wide and 1.5 meter wide.

(2) Longitudinal slope of scouring sluice

Longitudinal cross section of new scouring sluice



① Conditions for hydraulic design of scouring sluice

- ✓ Target discharge (normal discharge): $Q_m = 2.00$ m^3/sec
- ✓ Maximum diameter of soil particle scoured: $d_{max} = 40$ mm
- ✓ River bed slope: $I_u = 1{:}100$ for upstream side of weir, $I_d = 1{:}60$ for downstream side
- ✓ Roughness coefficient of scouring sluice: $n = 0.020$

② Longitudinal slope of scouring sluice

The scouring sluice channel is designed so that it has a supercritical flow at the normal discharge that can flush away stones of d_{max} through fully-opened gates.

- ✓ Critical velocity: $V_c = \sqrt{20 \times d_{max}} = \sqrt{20 \times 0.04} = 0.89$ m/sec

✓ Critical depth: $h_c = \frac{V_c^2}{g} = \frac{0.89^2}{9.8} = 0.08\ \text{m}$

✓ Critical slope: $I_c = \left(0.020 \times \frac{0.89}{0.08^{2/3}}\right) = 0.00919 = 1:109$

Therefore, the longitudinal slope of the scouring sluice can be the same as I_d and is determined to be 1:60.

The longitudinal slope of the scouring sluice = I_d = 1/60.

(3) Downstream apron of scouring sluice

① Length of downstream apron of scouring sluice

A downstream apron is constructed to avoid possible scouring by water flow through the scouring sluice. The length of the downstream apron is determined as follows (See Headwork Design Standard of MAFF, page 207);

The length of the downstream apron is obtained using the Bligh's formula.

$$l_1 = 0.9 \times C\sqrt{D_1} = 0.9 \times 4 \times \sqrt{5.40} = 8.37\ \text{m}$$

Where;

l_1 = Length of the downstream apron (m)

D_1 = Elevation difference between the gate top and the top at the apron downstream end (i.e. D_1 = EL 254.40 m − EL 249.00 m = 5.40 m)

C = Bligh's coefficient, which is 4 for boulders, gravel and sand

Thus, the length of the downstream apron is determined to be 10.0 m to secure creep length.

② Creep length of scouring sluice

1) Method of creep length examination

It is essential to secure a creep length along with ground-contact surface of the weir or back face of bank protection retaining walls for prevention of piping. The creep length to prevent piping is calculated using two methods: Bligh's and Lane's methods. After comparing two values to each other, the larger one is adopted as the minimum length of creep length (See Headwork Design Standard of MAFF, page 192).

Assuming the downstream one is zero, to be safer, the maximum water level difference between up- and downstream sides is calculated. Weep holes are installed in the cutoff wall at the downstream end of the downstream apron, to reduce uplift pressure. Therefore, we do not consider the width of cutoff wall as a part of the creep length.

2) Examination of creep length

i) Bligh's method

$$S \geq C \times \Delta H = 4 \times 5.40 = 21.60\ \mathrm{m} \leq 27.20\ \mathrm{m}$$

where

S = Creep length along with ground-contact surface of the weir (m)

(i.e. S = 1.00 + 1.90 +1.50 × 2 + 1.00×2 +18.50 = 26.40 m)

C = Bligh's coefficient, which is 4 for boulders, gravel and sand

ΔH = the maximum water level difference between up- and downstream sides

= 5.40 m

ii) Lane's method

$$L \geq C' \times \Delta H = 2.5 \times 5.40 = 13.50\ \mathrm{m} \leq 14.07\ \mathrm{m}$$

where

L = Weighted creep length (m), $L = \sum l_V + (1/3)\sum l_h$

L = (1.00 +1.90 + 1.50×2 + 1.00×2) + 1/3 ×18.50 = 14.07 m

C' = Lane's weighted coefficient, which is 2.5 for boulders, gravel and stones

ΔH = the maximum water level difference between up- and downstream sides

= 5.40 m

As a result, the downstream apron length of 10.0 m satisfies both inequalities above and is inferred to be safe.

③ Thickness of downstream apron of scouring sluice

The thickness of the downstream apron is obtained from the following inequality concerning the uplifting pressure balance (See Headwork Design Standard of MAFF, page 207).

$$t \geq \frac{4}{3} \times \frac{\Delta H - H_f}{\gamma - 1}$$

Where;

t = Apron thickness at a point of interest (m)

ΔH = the maximum water level difference between up- and downstream sides

= 5.40 m

H_f = Head loss of percolating water to the point of interest

γ = Specific gravity of the material of weir and apron, γ = 2.35 tf/m^3

$\frac{4}{3}$ = Safety factor

- Overall creep length

  L_X = 1.00 + 1.90 + 1.50 × 2 +1.00 × 2 + 18.50 = 26.40 m

- Creep length to Point A

  L_A = 1.00 + 1.90 + 1.50 × 2 +1.00 × 2 + 8.50 = 16.40 m

- Head loss of percolating water to Point A

  $H_f = (L_A/L_x) \times \Delta H = (16.40/26.40) \times 5.40 = 3.35$ m

- Apron thickness

$$t \geq \frac{4}{3} \times \frac{\Delta H - H_f}{\gamma - 1} = \frac{4}{3} \times \frac{5.40 - 3.35}{2.35 - 1} = 2.10\,\mathrm{m}$$

Consequently, the apron thickness at Point A, t, is determined to be 2.10 m.

(4) Riverbed protection of scouring sluice

① Length of riverbed protection of scouring sluice

In addition to the downstream apron, riverbed protection is implemented to avoid possible scouring by water flow over the fixed weir. The length of riverbed protection is determined as follows (See Headwork Design Standard of MAFF, page 259):

The length of riverbed protection is obtained using the Bligh's formula.

$$L = L_B - l_a$$

$$L_B = 0.67 \times C\sqrt{H_a \times q} \times \mathrm{f} = 0.67 \times 4 \times \sqrt{5.40 \times 19.97} \times 1.5 = 41.75\,\mathrm{m}$$

Where;

L = Length of riverbed protection

L_B = Total of apron length l_a and riverbed protection length L

H_a = Elevation difference between the weir crown and downstream-side water level during drought period H_a = EL 254.40 m − WL 249.00 m = 5.40 m

q = Design flood discharge per unit width, q = 19.97 m^3/sec/m

f = Safety factor of sluice-gate weir, f = 1.5

L = 41.75 − 14.90 = 26.85 m

Thus, the length of riverbed protection is determined to be 12.0 m, that is 3 m × 3 rows.

② Riverbed protection block of scouring sluice

Riverbed protection blocks must be stable against water flow. The approximate weight of a riverbed protection block is determined as follows (See Headwork Design Standard of MAFF, page 259);

$$W \geq 3.77 \times A \times \frac{V^2}{2g} = 3.77 \times 1.35 \times \frac{5.25^2}{2 \times 9.8} = 7.16\,\mathrm{tf}$$

Where;

W = Weight of a riverbed protection block (tf)

A = Area of a block exposed perpendicular to water flow (m^2)

A = 0.50 × 2.70 = 1.35 m^2

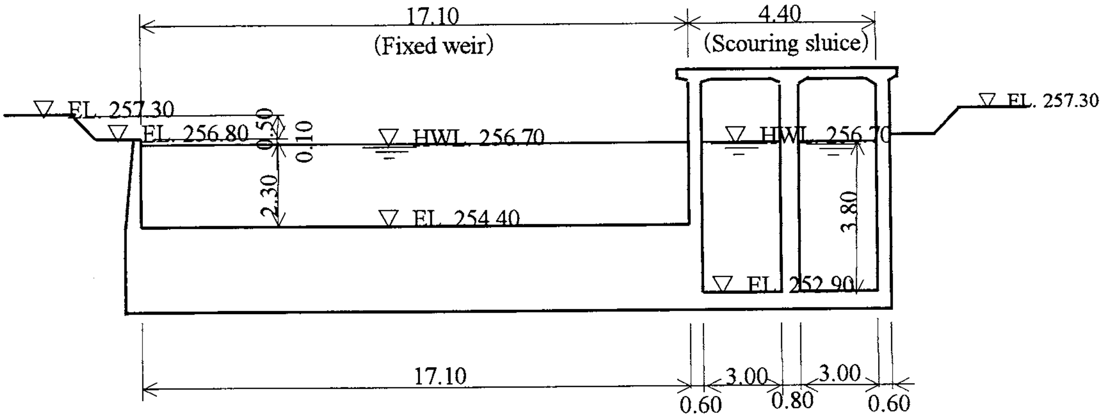
V = Velocity of water when it hits blocks, V = 5.25 m/sec

g = acceleration of gravity = 9.8 m/sec^2

Thus, riverbed protection blocks are crossing type and made of in-place concrete. The size of a block is 2.70 m in width, 2.70 m in length and 1.00 m in height, and the weight is 8.75 of each.

5-9. 3 Flood Water Level on the Upstream Side of Headworks after Rehabilitation

Elevation of Maliana I headworks



We presume the design flood discharge is HWL. 256.70 m.

(1) Fixed weir

Water depth, m	:	hw = HWL. 256.70 m − EL. 254.40 m = 2.30 m
Cross-sectional flow area, m^2	:	$Aw = 16.90 \times 2.30 = 38.87$ m^2
Flow velocity, m/sec	:	$Vw = 189.7 / 38.87 = 4.88$ m/sec
Velocity head, m	:	$Hvw = 4.88^2 / (2 \times 9.8) = 1.22$ m
Energy head, m	:	$H = 2.30 + 1.22 = 3.52$ m
Discharge, m^3/sec	:	$Q = 1.70 \times 17.10 \times 3.52^{3/2} = 192.0$ m^3/sec

(2) Scouring sluice (Concrete section)

Water depth, m	:	hs = HWL. 256.70 m − EL. 252.90 m = 3.80 m
Cross-sectional flow area, m^2	:	$As = 3.00 \times 3.80 \times 2 = 22.80$ m^2
Wetted perimeter, m	:	$Ps = (3.00 + 3.80 \times 2) \times 2 = 21.20$ m
Hydraulic radius, m	:	$Rs = 22.80 / 21.20 = 1.075$ m
Roughness coefficient	:	$n_s = 0.020$
River bed slope	:	$Is = 1 / 100$
Flow velocity, m/sec	:	$Vs = 1 / 0.020 \times 1.075^{2/3} \times (1 / 100)^{0.5} = 4.88$ m/sec
Discharge, m^3/sec	:	$Qs = 22.80 \times 5.25 = 119.8$ m^3/sec
Total discharge, m^3/sec	:	$Q = 192.0 \times 119.8 = 311.8 \approx 310$ m^3/sec

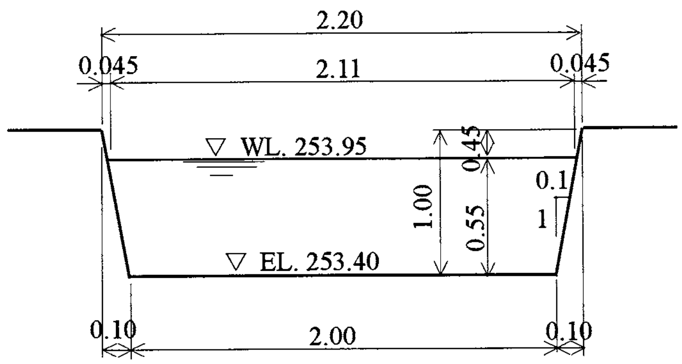
Therefore, the flood water level on the upstream side of headworks after rehabilitation is HWL. 256.70 m.

5-10. 1 Hydraulic Design Conditions and Hydraulic Longitudinal Profile

(1) Hydraulic design conditions

1) Design intake discharge : Q = 1.37 m^3/sec
2) Design intake water level : NWL. 254.30 m
3) Design intake width : W = 1.50 × 2 + 0.60 = 3.60 m
4) Design intake bottom elevation : EL. 253.60 m
5) Boundary hydraulic conditions at the beginning point of main canal :

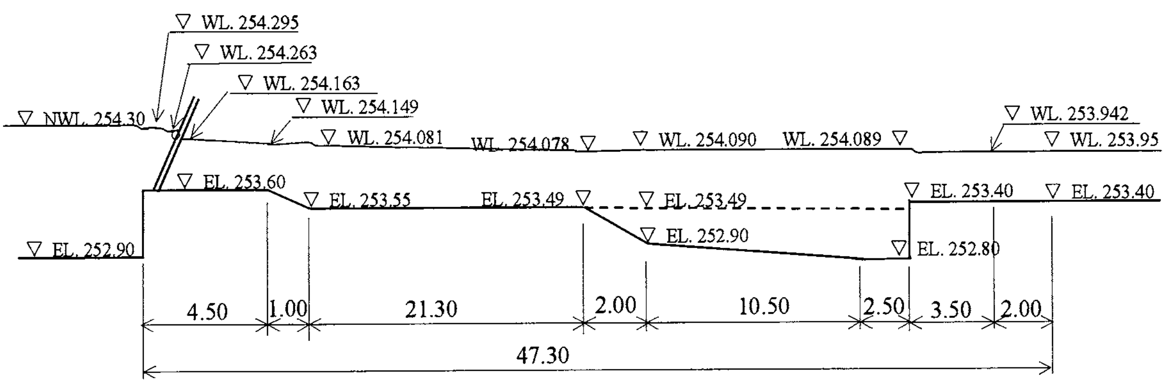
Cross Section of at the Beginning Point of Main Canal



- Design depth : h = 0.55 m
- Cross-sectional flow area : A = 1/2 × (2.00 + 2.11) × 0.55 = 1.13 m^2
- Wetted perimeter : P = 2.00 + 0.55 × 2 = 3.11 m^2
- Hydraulic radius : R = 1.13 / 3.11 = 0.364 m
- Roughness coefficient : n = 0.020
- Bed slope : I = 1 / 400
- Flow velocity : V = 1 / 0.020 × $0.364^{2/3}$ × $(1 / 400)^{0.5}$ = 1.27 m/sec
- Discharge : Q = 1.13 × 1.27 = 1.44 > Design Q = 1.37 m^3/sec

(2) Longitudinal profile

Longitudinal profile of intake works and sediment settling basin



5-10. 2 Hydraulic Calculations

(1) Water level decline due to water intake

$$\Delta he = fe \times \frac{V_1^2}{2g} + \frac{V_1^2 - V_0^2}{2g}$$

Where;

Δhe = Water level decline due to water intake, m

fe = Coefficient of loss due to water intake, fe = 0.20 for rectangular shape with rounded corners

V_1 = Flow velocity after water intake, m/sec

V_0 = Flow velocity before water intake, V_0 = 0 m/sec

g = acceleration of gravity = 9.80 m/sec^2

Assuming Δhe = 0.005 m, we have

Depth after water intake	:	h_1 = NWL. 254.30 − 0.005 − EL. 252.90 = 1.395 m
Width of intake opening	:	$B_1 = 1.50 \times 2 + 0.60 = 3.60$ m
Cross-sectional flow area after water intake	:	$A_1 = 3.60 \times 1.395 = 5.022$ m^2
Flow velocity after water intake	:	$V_1 = 1.37 / 5.022 = 0.27$ m/sec

These values result in

$$\Delta he = 0.20 \times \frac{0.27^2}{2 \times 9.80} + \frac{0.27^2 - 0^2}{2 \times 9.80} = 0.001 + 0.004 = 0.005 \text{ m},$$

And Δhe coincides with the above assumed value. Therefore,

Water level after water intake = NWL. 254.30 − 0.005 = WL. 254.295 m.

(2) Water level decline due to step

$$\Delta hc = fc \times \frac{V_2^2}{2g} + \frac{V_2^2 - V_1^2}{2g}$$

Where;

Δhc = Water level decline due to step (i.e. difference in channel bottom elevations), m

fc = Coefficient of loss due to step

V_2 = Flow velocity after passing step, m/sec

V_1 = Flow velocity before passing step, V_1 = 0.27 m/sec

Assuming Δhc = 0.019 m;

Depth after passing step	:	h_2 = WL. 254.295 − 0.019 − EL. 253.60 = 0.676 m
Width of intake opening	:	$B_2 = 1.50 \times 2 + 0.60 = 3.60$ m
Cross-sectional flow area after passing step	:	$A_2 = 3.60 \times 0.676 = 2.434$ m^2
Flow velocity after passing step	:	$V_2 = 1.37 / 2.434 = 0.56$ m/sec

Coefficient of loss due to step : $A_2/A_1 = 2.434 / 5.022 = 0.48$, hereby fc = 0.44

These values result in

$$\Delta hc = 0.44 \times \frac{0.56^2}{2 \times 9.80} + \frac{0.56^2 - 0.27^2}{2 \times 9.80} = 0.007 + 0.016 = 0.019\,\text{m},$$

And Δhc coincides with the above assumed value. Therefore,

Water level after passing step = WL. 254.295 − 0.019 = WL. 254.276 m.

(3) Water level decline due to pier

$$\Delta hp = \frac{Q^2}{2g} \times \left(\frac{1}{C^2 B_3^2 (h_2 - \Delta hp)^2} - \frac{1}{B_2^2 h_2^2} \right)$$

Where;

Δhp = Water level decline due to pier(s), m

Q = Design discharge, that is 1.37 m^3/sec

C = Coefficient of loss due to pier(s), C = 0.92 for round shape

B_3 = Width after passing pier(s), $B_3 = 1.50 \times 2 = 3.00$ m

Assuming Δhp = 0.013 m;

Depth after passing pier(s)	:	h_3 = WL. 254.276 − 0.013 − EL. 253.60 = 0.663 m
Width after passing pier(s)	:	$B_3 = 1.50 \times 2 = 3.00$ m
Cross-sectional flow area after passing pier(s)	:	$A_3 = 3.60 \times 0.663 \times 2 = 1.989$ m^2
Flow velocity after passing pier(s)	:	$V_3 = 1.37 / 1.989 = 0.69$ m/sec

These values result in

$$\Delta hp = \frac{1.37^2}{2 \times 9.80} \times \left(\frac{1}{0.92^2 \times 3.00^2 \times (0.676 - 0.013)^2} - \frac{1}{3.60^2 \times 0.676^2} \right) = 0.013,$$

And Δhc coincides with the above assumed value. Therefore,

Water level after passing pier(s) = WL. 254.276 − 0.013 = WL. 254.263 m.

(4) Water level decline due to screen

$$\Delta hr = fr \times \frac{V_4^2}{2g} + \frac{V_4^2 - V_3^2}{2g}$$

Where;

Δhr = Water level decline due to screen, m

fr = Coefficient of loss due to screen

i.e. $fr = \beta \cdot \sin\theta \cdot \left(\frac{t}{b}\right)^{4/3} = 2.34 \times \sin 76° \times \left(\frac{1.6}{18.4}\right)^{4/3} = 0.09$

V_4 = Flow velocity after passing screen, m/sec

V_3 = Flow velocity before passing screen, V_3 = 0.69 m/sec

β = Shape coefficient of screen bars, β = 2.34 for rectangular shape

θ = Angle of screen bars to the level, θ = 76°

t = Thickness of screen bars, t = 1.6 mm

b = Opening between screen bars, b = 28.4 mm

Assuming Δhr = 0.002 m;

Depth after passing screen	:	h_4 = WL. 254.263 − 0.002 − EL. 253.60 = 0.661 m
Width of screen	:	B_4 = 1.50 × 2 = 3.00 m
Cross-sectional flow area after passing screen	:	A_4 = 1.50 × 0.661 × 2 = 1.983 m^2
Wetted perimeter after passing screen	:	P_4 = (1.50 + 0.661 × 2) × 2 = 5.664 m
Hydraulic radius after passing screen	:	R_4 = 1.983 / 5.644 = 0.351 m
Flow velocity after passing pier(s)	:	V_4 = 1.37 / 1.989 = 0.69 m/sec
Hydraulic gradient after passing screen	:	$I_4 = (0.015 \times 0.69 / 0.351^{2/3})^2 = 0.000433$

These values result in

$$\Delta hr = 0.09 \times \frac{0.69^2}{2 \times 9.80} + \frac{0.69^2 - 0.69^2}{2 \times 9.80} = 0.002\,\text{m},$$

And Δhr coincides with the above assumed value. However, water level decline greatly depends on condition of clogging due to rubbish. Therefore, considering such conditions, we determine Δhr = 0.100 m.

Water level after passing screen = WL. 254.263 − 0.100 = WL. 254.163 m.

(5) Water level decline due to friction at the intake

$$\Delta h_{f1} = \frac{I_4 + I_5}{2} \times L_4 + \frac{V_5^2 - V_4^2}{2g}$$

Where;

Δh_{f1} = Water level decline due to friction at the intake, m

I_5 = Hydraulic gradient at the downstream end of the intake

L_4 = Distance to the downstream end of the intake, L_4 = 4.50 m

V_5 = Flow velocity at the downstream end of the intake, m/sec

Assuming Δh_{f1} = 0.014 m;

Depth of the intake at its downstream end : h_5 = WL. 254.163 − 0.014 − EL. 253.60 = 0.549 m

Width of the intake at its downstream end	:	$B_5 = 1.50 \times 2 = 3.00$ m
Cross-sectional flow area of the intake at its downstream end	:	$A_5 = 1.50 \times 0.549 \times 2 = 1.647$ m^2
Wetted perimeter of the intake at its downstream end	:	$P_5 = (1.50 + 0.549 \times 2) \times 2 = 5.196$ m
Hydraulic radius of the intake at its downstream end	:	$R_5 = 1.647 / 5.196 = 0.317$ m
Flow velocity at the downstream end of the intake	:	$V_5 = 1.37 / 1.647 = 0.83$ m/sec
Hydraulic gradient at the downstream end of the intake	:	$I_5 = (0.015 \times 0.83 / 0.317^{2/3})^2 = 0.000717$

These values result in

$$\Delta h_{f1} = \frac{0.000433 + 0.000717}{2} \times 4.50 + \frac{0.83^2 - 0.69^2}{2 \times 9.80} = 0.014 \text{ m},$$

And Δh_{f1} coincides with the above assumed value. Therefore,

$$\begin{pmatrix}\text{Water level at the downstream - most} \\ \text{point of the intake}\end{pmatrix} = \text{WL.}254.163 - 0.014 = \text{WL.}254.149\text{m}$$

(6) Water level decline due to bends

$$\Delta h_b = f_b \times \frac{V_5^2}{2g} + \frac{V_6^2}{2g}$$

Where;

Δh_b = Water level decline due to bends, m

f_b = Coefficient of loss due to bends, $f_b = 1.0$

V_6 = Flow velocity at the upstream end of the connective canal

Assuming $\Delta h_b = 0.068$ m;

Depth of its connective canal at its upstream end	:	h_6 = WL. 254.149 − 0.068 − EL. 253.55 = 0.531 m
Width of the connective canal at its upstream end	:	$B_6 = 3.20$ m
Cross-sectional flow area of the connective canal at its upstream end	:	$A_6 = 3.20 \times 0.531 = 1.699$ m^2
Wetted perimeter of the connective canal at its upstream end	:	$P_6 = 3.20 + 0.531 \times 2 = 4.262$ m
Hydraulic radius of the connective canal at its upstream end	:	$R_6 = 1.699 / 4.262 = 0.399$ m
Flow velocity at the upstream end of the connective canal	:	$V_6 = 1.37 / 1.699 = 0.81$ m/sec
Hydraulic gradient at the upstream end of the connective canal	:	$I_6 = (0.015 \times 0.81 / 0.399^{2/3})^2 = 0.000503$

These values result in

$$\Delta h_b = 1.0 \times \frac{0.83^2}{2 \times 9.80} + \frac{0.81^2}{2 \times 9.80} = 0.068 \text{ m},$$

And Δh_{f1} coincides with the above assumed value. Therefore,

$$\begin{pmatrix}\text{Water level at the upstream - most} \\ \text{point of the branch canal}\end{pmatrix} = \text{WL}.254.149 - 0.068 = \text{WL}.254.081\text{m}$$

(7) Water level decline due to friction in the connective canal

$$\Delta h_{f2} = \frac{I_6 + I_7}{2} \times L_6 + \frac{V_7^2 - V_6^2}{2g}$$

Where;

Δh_{f2} = Water level decline due to friction in the connective canal, m

I_7 = Hydraulic gradient at the downstream end of the connective canal

L_6 = Distance to the downstream end of the connective canal, L_6 = 21.30 m

V_7 = Flow velocity at the downstream end of the connective canal, m/sec

Assuming Δh_{f2} = 0.003 m,

Depth of the connective canal at its downstream end	: h_7 = WL. 254.081 − 0.003 − EL. 253.49 = 0.588 m
Width of the connective canal at its downstream end	: B_7 = 3.20 m
Cross-sectional flow area of the connective canal at its downstream end	: A_7 = 3.20 × 0.588 × 2 = 1.882 m^2
Wetted perimeter of the connective canal at its downstream end	: P_7 = 3.20 + 0.588 × 2 = 4.376 m
Hydraulic radius of the connective canal at its downstream end	: R_7 = 1.882 / 4.376 = 0.430 m
Flow velocity at the downstream end of the connective canal	: V_7 = 1.37 / 1.882 = 0.73 m/sec
Hydraulic gradient at the downstream end of the connective canal	: $I_5 = (0.015 \times 0.73 / 0.430^{2/3})^2 = 0.000369$

These values result in

$$\Delta h_{f2} = \frac{0.000503 + 0.000369}{2} \times 21.30 + \frac{0.73^2 - 0.81^2}{2 \times 9.80} = 0.003 \text{ m},$$

And Δh_{f1} coincides with the above assumed value. Therefore,

$$\begin{pmatrix}\text{Water level at the downstream - most} \\ \text{point of the branch canal}\end{pmatrix} = \text{WL}.254.081 - 0.003 = \text{WL}.254.078\text{ m}$$

(8) Water level decline at the entrance of the sediment settling basin

$$\Delta h_t = \frac{I_7 + I_8}{2} \times L_7 + (1 - f_t) \times \frac{V_8^2 - V_7^2}{2g}$$

Where;

Δh_t = Water level decline at the entrance of the sediment settling basin, m

I_8 = Hydraulic gradient at the upstream end of the sediment settling basin

L_7 = Distance to the upstream end of the sediment settling basin, $L_7 = 2.00$ m

f_t = Coefficient of loss due to enlargement of cross section, $f_t = 0.50$

V_8 = Flow velocity at the upstream end of the sediment settling basin, m/sec

Assuming $\Delta h_t = 0.012$ m;

Depth of the sediment settling basin at its upstream end	:	h_8 = WL. 254.078 − 0.012 − EL. 253.49 = 0.600 m
Width of the sediment settling basin at its upstream end	:	B_8 = 8.00 m
Cross-sectional flow area of the sediment settling basin at its upstream end	:	$A_8 = 8.00 \times 0.600 \times 2 = 4.800$ m^2
Wetted perimeter of the sediment settling basin at its upstream end	:	$P_8 = 8.00 + 0.600 \times 2 = 4.800$ m
Hydraulic radius of the sediment settling basin at its upstream end	:	$R_8 = 4.800 / 9.200 = 0.522$ m
Flow velocity at the upstream end of the sediment settling basin	:	$V_8 = 1.37 / 4.800 = 0.29$ m/sec
Hydraulic gradient at the upstream end of the sediment settling basin	:	$I_8 = (0.020 \times 0.29 / 0.522^{2/3})^2 = 0.000080$

These values result in

$$\Delta h_t = \frac{0.000369 + 0.000080}{2} \times 2.00 + (1 - 1.50) \times \frac{0.29^2 - 0.73^2}{2g} = -0.012,$$

and Δh_t coincides with the above assumed value. Therefore,

$$\begin{pmatrix}\text{Water level at the entrance} \\ \text{of the settling basin}\end{pmatrix} = \text{WL}.254.078 + 0.012 = \text{WL}.254.090\,\text{m}$$

(9) Water Level Decline in the Sediment Settling Basin

$$\Delta h_{f3} = \frac{I_8 + I_9}{2} \times L_8 + \frac{V_9^2 - V_8^2}{2g}$$

Where;

Δh_{f3} = Water level decline due to friction in the sediment settling basin, m

I_9 = Hydraulic gradient at the downstream end of the sediment settling basin

L_8 = Distance to the downstream end of the sediment settling basin, $L_8 = 13.00$ m

V_9 = Flow velocity at the downstream end of the sediment settling basin, m/sec

Assuming $\Delta h_{f3} = 0.001$ m, we have

Depth of the sediment settling basin at its downstream end	:	h_9 = WL. 254.090 − 0.001 − EL. 253.45 = 0.639 m
Width of the sediment settling basin at its downstream end	:	B_9 = 8.00 m
Cross-sectional flow area of the sediment settling basin at its downstream end	:	$A_9 = 8.00 \times 0.639 = 5.112$ m^2
Wetted perimeter of the sediment settling basin at its downstream end	:	$P_9 = 8.00 + 0.639 \times 2 = 9.278$ m
Hydraulic radius of the sediment settling basin at its downstream end	:	$R_9 = 5.112 / 9.278 = 0.551$ m

basin at its downstream end	
Flow velocity at the downstream end of the sediment settling basin	: $V_9 = 1.37 / 5.112 = 0.27$ m/sec
Hydraulic gradient at the downstream end of the sediment settling basin	: $I_8 = (0.020 \times 0.27 / 0.551^{2/3})^2 = 0.000065$

These values result in

$$\Delta h_{f3} = \frac{0.000080 + 0.000065}{2} \times 13.00 + \frac{0.27 - 0.29}{2 \times 9.80} = 0.001\,\text{m},$$

and Δh_{f3} coincides with the above assumed value. Therefore,

$$\left(\begin{array}{c}\text{Water level at the downstream end}\\ \text{of the settling basin}\end{array}\right) = \text{WL.}254.090 + 0.001 = \text{WL.}254.089\,\text{m}$$

(10)Water Level Decline at the Entrance of the Intake Gate

$$\Delta h_g = (1 + f_g) \times \frac{V_{10}^2 - V_9^2}{2g} + \frac{I_9 + I_{10}}{2} \times L_9$$

Where;

Δh_g = Water level decline at the entrance of the intake gate, m

f_g = Coefficient of loss at the entrance of the intake gate, $f_g = 0.50$ for rectangular shape

V_{10} = Flow velocity at the intake gate, m/sec

L_9 = Distance to the downstream end of the intake gate, $L_9 = 3.50$ m

Assuming $\Delta h_g = 0.147$ m, we have

Depth of the intake gate at its downstream end	: h_{10} = WL. 254.089 − 0.147 − EL. 253.40 = 0.542 m
Width of the intake gate at its downstream end	: $B_{10} = 1.80$ m
Cross-sectional flow area of the intake gate at its downstream end	: $A_{10} = 1.80 \times 0.542 = 0.976$ m^2
Wetted perimeter of the intake gate at its downstream end	: $P_9 = 1.80 + 0.542 \times 2 = 2.884$ m
Hydraulic radius of the intake gate at its downstream end	: $R_{10} = 0.976 / 2.884 = 0.339$ m
Flow velocity at the downstream end of the intake gate	: $V_{10} = 1.37 / 0.976 = 1.40$ m/sec
Hydraulic gradient at the downstream end of the intake gate	: $I_{10} = (0.015 \times 1.40 / 0.339^{2/3})^2 = 0.001873$

These values result in

$$\Delta h_g = (1 + 1.50) \times \frac{1.40^2 - 0.27^2}{2 \times 9.80} + \frac{0.000065 + 0.001873}{2} \times 3.50 = 0.147\,\text{m},$$

And Δh_g coincides with the above assumed value. Therefore,

$$\left(\begin{array}{c}\text{Water level at the downstream end}\\ \text{of the intake gate}\end{array}\right) = \text{WL.}254.089 - 0.147 = \text{WL.}254.942\,\text{m},$$

And

$$\left(\begin{array}{c}\text{Invert elevation at the downstream end}\\ \text{of the intake gate}\end{array}\right) = \text{WL}.254.942 - 0.542 = \text{WL}.254.400\text{ m}$$

(11) Water level decline at the transition section

$$\Delta h_i = (1 - f_i) \times \frac{V_{11}^2 - V_{10}^2}{2g} + \frac{I_{10} + I_{11}}{2} \times L_{10}$$

where

Δh_g = Water level decline at the transition section, m

f_g = Coefficient of loss due to transition (enlargement), f_i = 0.20

V_{11} = Flow velocity at the beginning point (B.P.) of mail canal, V_{11} = 1.27 m/sec

L_{10} = Distance of the transition section, L_{10} = 2.00 m

I_{11} = Hydraulic gradient at the B.P. of mail canal, I_{11} = 0.002500

These values result in

$$\Delta h_i = (1.0 - 0.2) \times \frac{1.27^2 - 1.40^2}{2 \times 9.80} + \frac{0.001873 + 0.002500}{2} \times 2.00 = -0.010\text{ m},$$

Therefore, if we determine Δh_i = −0.008 for the bed slope from the intake gate to the B.P. of the main canal not to be inverse,

Water level at the B.P. of the main canal = WL. 253.942 + 0.008 = WL. 253.950 m, and
Invert elevation at the B.P. of the main canal = WL. 253.950 − 0.550 = WL. 253.400 m.

5-11 Balance Sheet for O/M Cost and Water Fee Collecting by Year

			The First Cycle						The Second Cycle							The Third Cycle																				
			Year					Average	Year					Average	Average	Year					Average	Year					Average	Average	Year					Average	Average	
	Item	Unit price (US$)	1	2	3	4	5	1-5	6	7	8	9	10	6-10	1-10	11	12	13	14	15	11-15	16	17	18	19	20	16-20	11-20	21	22	23	24	25	21-25	11-25	remarks
A. Salary of WUA executive	not estimated																																			for 4 cadres of WUA
B. Personnel cost for instruction (estimating only allowance for gate keepers up to 10th year)	1)DIO adviser	240	240	240	240	240	240	240	240	240	240	240	240	240	240																					
	2)O/M coordinator	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800																					salary for coordinator
	3)Gate keeper	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	salary for gate keeper
	Sub total(1)+2)+3)		2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	2,940	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	
C.Water distribution work	1)Turnout gate keeper(22perso	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	2,640	salary of turn-out gate keepers
	2)Intake gate keeper (1person)	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	salary of intake gate keeper
	Sub total(1)+2)	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	
D. Gate maintenance cost 1.Intake gate (8 gates)	1)Oiling	628	0	628	628	628	628	502	628	628	628	628	628	628	565	628	628	628	628	628	628	628	628	628	628	628	628	628	628	628	628	628	628	628	628	taking place once a year
	2)Re-painting	3,364	0	0	0	0	0	0	1,121	1,121	1,121	0	0	673	336	0	1,121	1,121	1,121	0	673	0	0	0	0	1,121	224	449	1,121	1,121	0	0	0	449	449	once in 7 years, dividing into 3-times
	3)Water seal rubber exchange	9,346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,115	623	3,115	3,115	0	0	0	1,246	935	0	0	0	0	0	0	623	once in 15 years, dividing into 3-times
	Sub total (1)+2)+3)		0	628	628	628	628	502	1,750	1,750	1,750	628	628	1,301	902	628	1,750	1,750	1,750	3,743	1,924	3,743	3,743	628	628	1,750	2,098	2,011	1,750	1,750	628	628	628	1,077	1,700	
2.Turn out gates (65 gates)	1)Oiling	790	0	790	790	790	790	632	790	790	790	790	790	790	711	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	790	taking place once a year
	2)Re-painting	5,467	0	0	0	0	0	0	1,822	1,822	1,822	0	0	1,093	547	0	1,822	1,822	1,822	0	1,093	0	0	0	0	1,822	364	729	1,822	1,822	0	0	0	729	729	once in 7 years, dividing into 3-times
	3)Water seal rubber exchange	12,150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,050	810	4,050	4,050	0	0	0	1,620	1,215	0	0	0	0	0	0	810	once in 15 years, dividing into 3-times
	Sub total (1)+2)+3)		0	790	790	790	790	632	2,612	2,612	2,612	790	790	1,883	1,257	790	2,612	2,612	2,612	4,840	2,693	4,840	4,840	790	790	2,612	2,774	2,734	2,612	2,612	790	790	790	1,519	2,329	
E.Facility repairing cost	1)Riverbed protection work	869	0	869	869	869	869	695	869	869	869	869	869	869	782	869	869	869	869	869	869	869	869	869	869	869	869	869	869	869	869	869	869	869	869	taking place once a year
	2)Bank protection work	2,737	0	2,737	2,737	2,737	2,737	2,190	2,737	2,737	2,737	2,737	2,737	2,737	2,463	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737	
	3)Main canal	1,373	0	1,373	1,373	1,373	1,373	1,099	1,373	1,373	1,373	1,373	1,373	1,373	1,236	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	1,373	
	4)Ramaskorasecondary canal	2,645	0	2,645	2,645	2,645	2,645	2,116	2,645	2,645	2,645	2,645	2,645	2,645	2,380	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	2,645	
	5) Rotabau secondary canal	2,668	0	2,668	2,668	2,668	2,668	2,135	2,668	2,668	2,668	2,668	2,668	2,668	2,401	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	2,668	
	Sub-total (1)+2)+3)+4)+5)	10,293	0	10,293	10,293	10,293	10,293	8,234	10,293	10,293	10,293	10,293	10,293	10,293	9,263	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	10,293	
Total (D+E)			0	11,710	11,710	11,710	11,710	9,368	14,654	14,654	14,654	11,710	11,710	13,477	11,423	11,710	14,654	14,654	14,654	18,875	14,910	18,875	18,875	11,710	11,710	14,654	15,165	15,037	14,654	14,654	11,710	11,710	11,710	12,888	14,321	
F.O/M Routine work 1.Dredging	1)scouring of sediment setting basic of intake facility	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	240	270x30%=80m3
	2)scouring of sediment setting basin in main canal	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	105x10%=10m3
	3)sediment evacuation from main canal	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	264	(160+15)x50%=88m3
	4)Sediment evacuation from Ramaskora secondary canal	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	(160+15)x35%=62m3
	5)Sediment evacuation from Ritabau secondary canal	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	81	(160+15)x15%=27m3
	Sub total(1)+2)+3)+4)+5)	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	801	
2.Weeding in canals	1)Main canal	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	230	25% of full time
	2)Ramaskora secondary canal	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	593	25% of full time
	3)Ritabau secondary canal	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	788	25% of full time
	Sub total(1)+2)+3)	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610		1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	1,610	
Total (F=1+2)		2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	2,411	
Total(B+C+D+E+F)		(US$)	8,171	19,881	19,881	19,881	19,881	17,539	22,825	22,825	22,825	19,881	19,881	21,647	19,593	17,841	20,785	20,785	20,785	25,006	21,040	25,006	25,006	17,841	17,841	20,785	21,296	21,168	20,785	20,785	17,841	17,841	17,841	19,018	20,451	
O &M cost/ha	① per ha	1,050 ha	7.8	18.9	18.9	18.9	18.9	16.7	21.7	21.7	21.7	18.9	18.9	20.6	18.7	17.0	19.8	19.8	19.8	23.8	20.0	23.8	23.8	17.0	17.0	19.8	20.3	20.2	19.8	19.8	17.0	17.0	17.0	18.1	19.5	
MAFFSubsidy (US$)		**70%**	5,719	13,917	13,917	13,917	13,917	12,277							Average																					
		30%							6,847	6,847	6,847	5,964	5,964	6,494	9,386						0						0	0						0		
Cost borne by WUA		Total(US$)	2,451	5,964	5,964	5,964	5,964	5,262	15,977	15,977	15,977	13,917	13,917	15,153	10,207	17,841	20,785	20,785	20,785	25,006	21,040	25,006	25,006	17,841	17,841	20,785	21,296	21,168	20,785	20,785	17,841	17,841	17,841	19,018	20,451	
		Average for 5 years(US$)	5,262						15,153							21,040						21,296							19,018							
A.Water fee collected (necessary)	per member household	1,500member	1.6	4.0	4.0	4.0	4.0	3.5	10.7	10.7	10.7	9.3	9.3	10.1	6.8	11.9	13.9	13.9	13.9	16.7	14.0	16.7	16.7	11.9	11.9	13.9	14.2	14.1	13.9	13.9	11.9	11.9	11.9	12.7	13.6	
	(US$/ha)	Average for 5 years	3.5						10.1							14.0						14.2							12.7							
	① per area (ha)	**1,050 ha**	**2.3**	**5.7**	**5.7**	**5.7**	**5.7**	**5.0**	**15.2**	**15.2**	**15.2**	**13.3**	**13.3**	**14.4**	**9.7**	**17.0**	**19.8**	**19.8**	**19.8**	**23.8**	**20.0**	**23.8**	**23.8**	**17.0**	**17.0**	**19.8**	**20.3**	**20.2**	**19.8**	**19.8**	**17.0**	**17.0**	**17.0**	**18.1**	**19.5**	
	(US$/ha)	Average for 5 years	5.0						14.4							20.0						20.3							18.1							

B.Amount of collected water fee(US$)

					The First Cycle						The Second Cycle							The Third Cycle																				
					Year					Average	Year					Average	Average	Year					Average	Year					Average	Average	Year					Average	Average	
	1-5year	6-10y.	11-25y.		1	2	3	4	5	1-5	6	7	8	9	10	6-10	1-10	11	12	13	14	15	11-15	16	17	18	19	20	16-20	11-20	21	22	23	24	25	21-25	11-25	Remarks
② Fixed amount per ha (75% of the total amount)	4.0	12.0	15.0	4$/ha to 5th year 11$/ha for 5th ~ 10th 16$/ha from 11th	4.0	4.0	4.0	4.0	4.0	4.0	12.0	12.0	12.0	12.0	12.0	12.0	8.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	Assuming annual cropping area at 1,400ha(cropping intensity 133%). Out of which, area in rainy season 1,050ha(75%) is taken for the fixed amount
③ collection per piece from 1 ha (25% of the total)	1.5	3.5	5.5	assuming 80% piece once in 5 years	1.5	1.5	1.5	1.5	1.2	1.4	3.5	3.5	3.5	3.5	2.8	3.4	2.4	5.5	5.5	5.5	5.5	4.4	5.3	5.5	5.5	5.5	5.5	4.4	5.3	5.3	5.5	5.5	5.5	5.5	4.4	5.3	5.3	
④ Total amount of collection	**5.5**	**15.5**	**20.5**		**5.5**	**5.5**	**5.5**	**5.5**	**5.2**	5.4	**15.5**	**15.5**	**15.5**	**15.5**	**14.8**	15.4	10.4	**20.5**	**20.5**	**20.5**	**20.5**	**19.4**	20.3	**20.5**	**20.5**	**20.5**	**20.5**	**19.4**	20.3	20.3	**20.5**	**20.5**	**20.5**	**20.5**	**19.4**	20.3	20.3	**Total amount of collection for 25 years**
⑤ rest amount per ha(④−①)					3.2	▲0.2	▲0.2	▲0.2	▲0.5		0.3	0.3	0.3	2.2	1.5			3.5	0.7	0.7	0.7	▲4.4		▲3.3	▲3.3	3.5	3.5	▲0.4			0.7	0.7	3.5	3.5	2.4			**408.2 US$/ha**
⑥ cumulative reserve per ha(⑤+⑧)					3.2	3.0	2.8	2.7	2.3		2.6	2.9	3.2	5.5	7.2			10.8	11.6	12.5	13.4	9.2		6.0	2.8	6.4	10.0	9.7			10.6	11.4	15.1	18.8	21.5			**428,610 US$**
⑦ interest per ha	1.5%	1.5%	1.5%	bank loan interest	-	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.1	0.1			0.2	0.2	0.2	0.2	0.1		0.1	0.0	0.1	0.1	0.1			0.2	0.2	0.2	0.3	0.3			
⑧ after adding interest per ha					3.2	3.0	2.9	2.8	2.3		2.6	3.0	3.3	5.6	7.3			10.9	11.8	12.7	13.6	9.3		6.1	2.8	6.4	10.1	9.9			10.7	11.6	15.3	19.1	21.9			
⑨ Total amount of reserve(treatable amount) : ⑥x1,050 ha					3,324	3,182	3,037	2,891	2,422		2,761	3,104	3,453	5,898	7,635			11,488	12,412	13,350	14,301	9,810		6,424	2,987	6,771	10,612	10,350			11,257	12,177	16,099	20,080	22,948			