Euroconsult Mott MacDonald bv in association with
Mott MacDonald Ltd., PT. Mott MacDonald Indonesia, PT. Phibetha
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DED Report

31 March 2022

Revised final

Merauke Irrigation Project

Consultancy Services for: Project Preparation Consultant (PPC) Firm for Development of the Merauke Irrigation System in Papua, Indonesia Phase-I

For the Directorate of Irrigation and Lowland, Directorate General of Water Resources, Ministry of Public Works and Housing, Republic of Indonesia
ADB Loan No. 3455-INO – Accelerating Infrastructure Delivery through Better Engineering Services Project (ESP)

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
1	16-02-2022	Johanes Wibowo Hadi Nugraha Hariyanto			Draft
2	24-02-2022	Johanes Wibowo Hadi Nugraha Hariyanto	Wicher Boissevain David Meigh Erwin Hofman	Hero Heering	Final draft
3	30-03-2022	Johanes Wibowo Hadi Nugraha Hariyanto	Wicher Boissevain Warsito Siswowiyoto David Meigh	Hero Heering	Final
4	31-03-2022	Johanes Wibowo David Meigh	Wicher Boissevain Warsito Siswowiyoto	Hero Heering	Revised final

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Foreword

This DED Report for the Development of the Merauke Irrigation System in Papua, Phase-I is based on (1) the Terms of Reference (ToR) provided by the Directorate of Irrigation and Lowlands, Directorate General of Water Resources (DGWR), Ministry of Public Works and Housing (MPWH) with the Request for Proposal (RFP) of 12 October 2018, (2) the Technical Proposal submitted on 19 November 2018, and (3) the Contract for Consulting Services No. KU.02.10/Ai/VI/17 between the Directorate of Irrigation and Lowlands and Euroconsult Mott MacDonald BV in joint venture with Mott MacDonald Ltd., PT Mott MacDonald Indonesia, PT Phibetha Kalamwijaya, PT Intimulya Multikencana and PT Giss Konsultan.

This DED Report describes the TA team's detailed engineering designs for the phase-2 irrigation lowland schemes in Merauke, which are based on the system plans (preliminary layout and concept designs) prepared in the Feasibility Study.

Chapter 1 of this report describes the Introduction of this project

Chapter 2 describes Land Survey and Mapping

Chapter 3 describes Irrigation Water and Canal Flows

Chapter 4 describes Canal and Control Structures Design

Chapter 5 describes Flood Protector

Chapter 6 describers Technical Specification

Chapter 7 describers Bill of Quantity

Chapter 8 describes Conclusion and Recommendation

In the Appendices we provide Derivation of Irrigation Water Requirement (**Appendix B**), Flood protection design (**Appendix C**), Canal Design (**Appendix D**), Structure Design (**Appendix E**), Pump Design (**Appendix F**), Layout Plan and Schematic Diagram (**Appendix G**), Drawings (**Appendix H**) and Bill of quantities (**Appendix I**).

The contents of the final draft DED Report was discussed on 22 and 25 March 2022 in an online (Zoom) meeting with the Client, the Client's team of advisers, and representatives of the ADB. Their comments and suggestions are presented in **Appendix A** in a comment/response matrix, which indicates how the comments and suggestions are incorporated in the final version of this report.

1 Introduction

1.1 Brief history of the project

1.1.1 Development of irrigation land in Merauke District during the Dutch Era

Lowland irrigation (LLIrr) development in Merauke District has been carried out since the Dutch era, at which time the Dutch Government began to think about the development of an irrigation area between Kumbe River and Maro River. Studies and planning were carried out in the late 1940's decade.

At that time, it was planned to develop fully technical irrigation system in the planned area, covering an area of approximately 12 thousand hectares, which was called the Koembe Rijstproject. The original field condition was that the swamps were affected by the tides but farmers had to pump high tide levels onto the fields. It is planned to apply fully mechanized farming methods, considering the use of very limited availability of labour. The source of water for the Koembe Rijstproject irrigation network is from S. Kumbe, where a free intake was to be built at a point of about 80 km inland from the mouth River Kumbe, and the flow is directly pumped into the primary irrigation canal. The primary channel is 35 km long before reaching the development area by gravity.

Figure 1-1 Koembe Rijstproject location

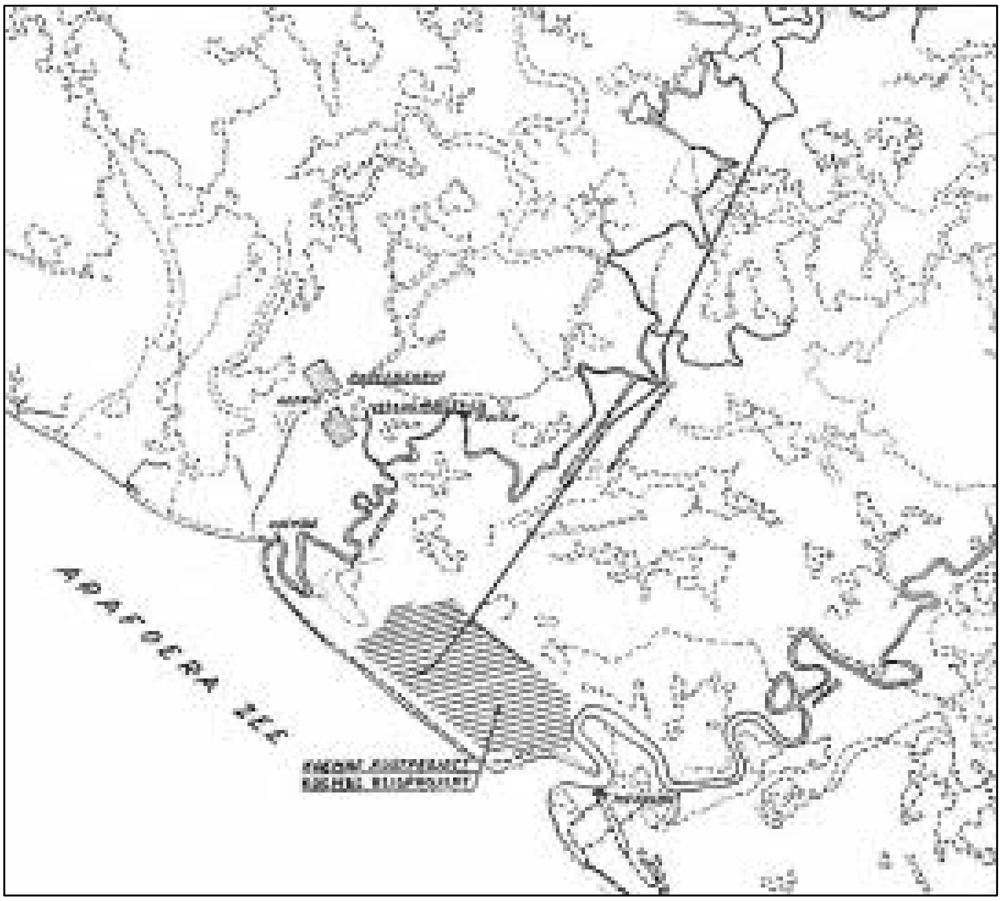
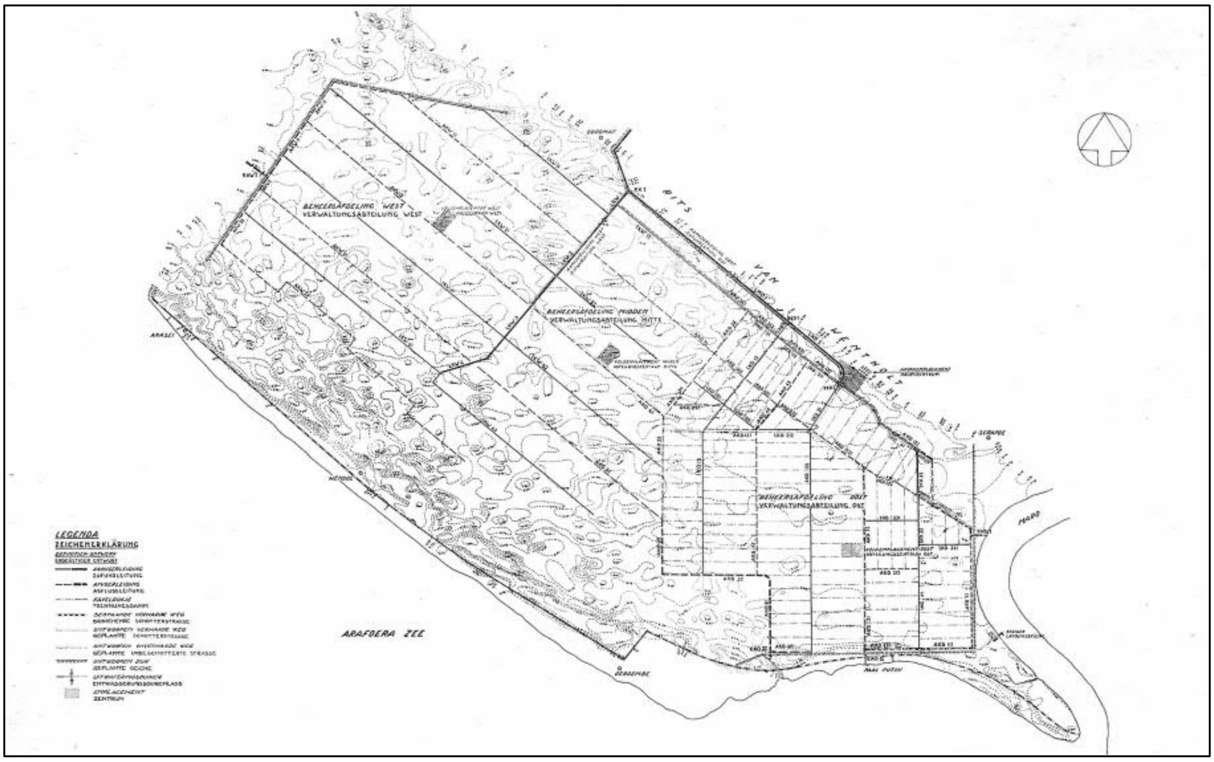


Figure 1-2 Koembe Rijstproject Situation



To support the Kumbe irrigation development plan, an experimental field was built in Kurik, with a development area of 400 Ha which is divided into 2 blocks of 200 Ha each, namely the North Sawah Block and the South Sawah Block. This experimental garden was established in the 1950s, with the aim of obtaining an effective way of managing the Kumbe Rijstpoject. In the end, only a part of the Koembe Rijstpoject was built, for instance the area around Serapu and Gudang Arang; the rest has not been implemented because of the political situation.

The water source of the Kurik experimental field is from Rawa Mayo which is connected to the Gali Ephata Reservoir assisted by a pumping station (Pump I). The Gali Ephata reservoir is estimated to have a capacity of 2.5-2.6 million m3. Then the water from Gali Ephata at an elevation of +5.25 m flows through the front channel to the second pumping station (Pump II) before the flow reaches North and South Sawah. The Second Pumping Station pumps irrigation water from an elevation of +5.25 m to an elevation of approximately +6.50 m to the Feeding Channel to the North and South Sawahs. The Pump Station I consist of 2 pumps, each driven by a diesel engine of 30 HP at 1450 RPM, with a pipe diameter of 12”. Pump Station II consists of 3 pumps, 15 HP each, with 10” pipes. The overall water requirement when given continuously uses an irrigation modulus of 1 ltr/sec/Ha; however, the design of pump is based on the maximum requirements of 2-3 l/s/ha as the pumping only carried out 8 hours per day.

The development of lowland irrigation (LLIrr) areas in Gudang Arang and Serapu (1400 Ha) which is also part of the Koembe Rijstproject, practically, it obtains supply water from S. Maro directly through free intake, because the planned supply system did not materialize. Originally water supply is planned from S. Kumbe through a technical irrigation system. At present, it means that the function of the canals are for drainage and supply at the same time.

1.1.2 Development of the Kurik, Salor, Semangga, Tanah Miring and Jagebob swamp irrigation areas since the 1980s until now

The development of the Kurik Lowland Irrigation area and its surroundings was carried out since the early 1980s, aimed to support the transmigration program. The area covering Kurik 1, 2, 3, 4, 5 and 6, Salor 1, 2, 3 and 4, Salor Kampung, Kumbe Kampung and Wapeko. Till now it has brought 14,300 ha of functional irrigation areas totally. The O&M management of these schemes is the responsibility of the Central Government, Papua Province Government, and Merauke District.

The development of the Semangga, Tanah Miring, and Jagebob areas was also carried out at almost the same time, with the same approach.

For Kurik schemes, the development was given a much more improved irrigation system than other areas in the beginning. But later on, the Government has given more attention to develop other areas. At this moment the level of the irrigation development is almost the same along with the issues. The main issues are: (i) the water level of the source is lower than the field levels, (ii) the limited amount of water available during the dry seasons, and (iii) water quality in the river is influenced by sea salinity during the dry seasons, (iv) At the end of some canals there is insufficient quantity of water or time during the high tide to abstract it.

Merauke District alone has 1,940,541 ha of swamp land, of which about 31,860 hectares or 1.64% have been developed for agriculture. At present in Merauke District there is a total of cultivated and drained and deforested swampland of 105,000 ha that could be developed for irrigation including the already irrigated land.

The descriptions of each existing Lowland Irrigation schemes in the DED area are presented in the next sub-chapter.

1.2 Existing lowland irrigation s chemes

In general, the existing schemes in Merauke subdistricts (Tanah Miring, Semangga, Kurik and Sermayam, except Jagebob) show promising and potential productivity for rice cultivation. They are mostly planted with rice twice a year with average production of 5-6 ton dried-husk rice (GKP)/ha in the first planting and 4-to-5-ton GKP/ha in the second planting. The cropping calendar for the first rice crop planting season starts in December with harvesting in February and March. The second rice crop is cultivated from April to July and not as shown by the BWS presentation as being started in September. As the agricultural production in these schemes is already high, further investment in these schemes may add limited benefits. Jagebob is the exception as the land is higher than the river and consequently, only a wet season mainly rainfed crop is generally grown. Substantial pumping is required but this would make second and third irrigated palawija crops viable.

Fresh water is available throughout the year under normal conditions from the Maro and Kumbe rivers. Saline water is reported to be an issue only during ‘extreme’ dry seasons. However, more frequent drought and increasing sea levels with climate change will increase the risk of salinity and saline intrusion. Water sources for the first crop include rainfall and tidal irrigation, while for a second crop in the dry season farmers use low-lift portable diesel driven pumps and modified hand tractors as pumps to irrigate their rice fields. According to farmers, there is no saline water in the canal system in normal dry years, and they can irrigate by pumping water directly from the canal. There seem to be no ‘official’ rules forbidding pumping of water directly from a main canal. However, farmers at the end of canals complain that insufficient water reaches them during the dry season. Near coastal schemes obtain water during the dry season from drainage from upper scheme areas.

Areas without irrigation, such as Jagebob, and on the periphery of irrigated areas are equipped with long retention ponds (long storage) that collect nearby rainwater. Water is pumped out of the ponds /drainage canals as rainfall recedes when the cultivated plants need a water supply. Due to percolation and evaporation this supply often only lasts a few weeks when there is no recharge from the river. BWS has proposed that canals are enlarged to act as long storages but farmers in more densely cultivated area are resistant to lose land for this purpose.

Most of these schemes can be classified as "*irigasi rawa sederhana* – simple lowland irrigation[1]", as irrigation canals also serve as drains and there are no structures to control or measure irrigation flows into collector units. In some schemes the intake is the primary and sometimes the only structure. As the first reach of the canal often passes through indigenous land it is overgrown whilst the intake control structure is set back on transmigration land. This risks the channel entrance and first reach of canal being reduced by sediment and the capacity further reduced by encroaching vegetation. This kind of system has proven to be much more efficient way to support agriculture activity. The improvement of this system would be to provide better water service to the agriculture practices.

Most of the rice farmers are transmigrants from Java with a tradition of cultivating rice at which they are proficient. The transmigrant houses are set in plots of about 0.25 ha, which are intended to be for gardens, orchards and occasional domestic animals and poultry that are usually tended by the women. During the dry season these areas tend to be less productive as they are set well above the natural water levels (rivers, ponds, drainage canals) and quickly dry out.

Table 1-1 Lowland irrigation schemes and structures built up to 2010

No.	Distrik	Sudah di-kembangkan (Ha)	PRASARANA YANG TELAH TERBANGUN											
			Waduk Gali (bh)	Long Storage (m)	Saluran Primer (m)	Saluran Sekunder (m)	Saluran Tersier (m)	Jalan Inspeksi (m)	Pintu Air Primer (bh)	Pintu Air Sekunder (bh)	Gorong-gorong (bh)	Tanggul Banjir (m)	Jembatan Usaha Tani (bh)	Rumah Pompa (bh)
1	Merauke	2,900			30,950	46,860			6	15	1		6	
2	Semangga	5,000		960	54,755	185,500	28,220	1,400	12	28	8	63,750	32	
3	Tanah Miring	8,600		1,000	134,205	371,287	11,170	6,400	15	10		27,800	33	
4	Jagebob	5,400		5,332	79,130	187,609			6	10	2		31	
5	Kurik	15,460	1	4,374	105,090	586,164	2,134	9,750	13	86	19	111,330	41	2
6	Malind													
7	Naukenjerai	2,000			17,800	8,250			2					
8	Okaba	1,500			13,300	25,700				4				
9	Sota	19												
10	Muting	700			3,750	13,600								
11	Ulilin	400			17,703	35,000								
12	Elikobel	800			15,142	42,476							2	
13	Kimaam	1,100			10,000	81,755							14	
	TOTAL	43,879	1	11,666	481,825	1,584,201	41,524	17,550	54	153	30	202,880	159	2

From the field survey, it can be concluded that some of the causes of damage to canals and buildings arise quite rapidly due to: (i) lack of attention to routine operations and maintenance efforts to prevent siltation in the canals, cultivation damage to canal banks, and disruption of flow by shrubs and water weeds; (ii) tidal variation in the rivers brings sedimentation into the canal, (iii) lack of farmer involvement in operation and maintenance activities, and (iv) low field resource capacity limits cooperation with farmer groups to combat degrading field conditions. Even though annual rehabilitation activities for parts of the network are always carried out, they do not systematically resolve the problem of under resourced field staff and hence the rate of system deterioration.

1.3 Existing lowland irrigation schemes managed by the Central Government

This sub-chapter describes the existing Lowland Irrigation schemes in the study area under the responsibility of the Central Government; those are: (i) Kurik, (ii) Jagebob, (iii) Sermayam, (iv) Tanah Miring, (v) Semangga. In the field, the Balai Wilayah Sungai (BWS) Papua represents the Central Government.

1.3.1 Kurik lowland irrigation scheme

The Kurik Lowland Irrigation scheme is on the right bank of the Kumbe River some 9.4 kilometres from the coast. The western, Kurik 1 Lowland Irrigation scheme is operated differently to other schemes by using two large pumping stations that were installed during the colonial era. The downstream pumping

[1] In fact the schemes under PUPR 2015 are classified as pump schemes.

station, called the “Mayo Pumping Station”, is operated by taking water up from Mayo swamp via a supply canal and pumping it into the Efata reservoir. A second Kurik Pumping Station which has diesel pumps should supply about 600 ha of rice fields. During the site visit the Mayo pumping station was inoperable and was reported as not having operated for some years. The Kurik pumping station has two pumps with only one pump currently operable. Operation and maintenance are key issues on these pumping stations and replacing the pumps with electric pumps should be a future consideration.

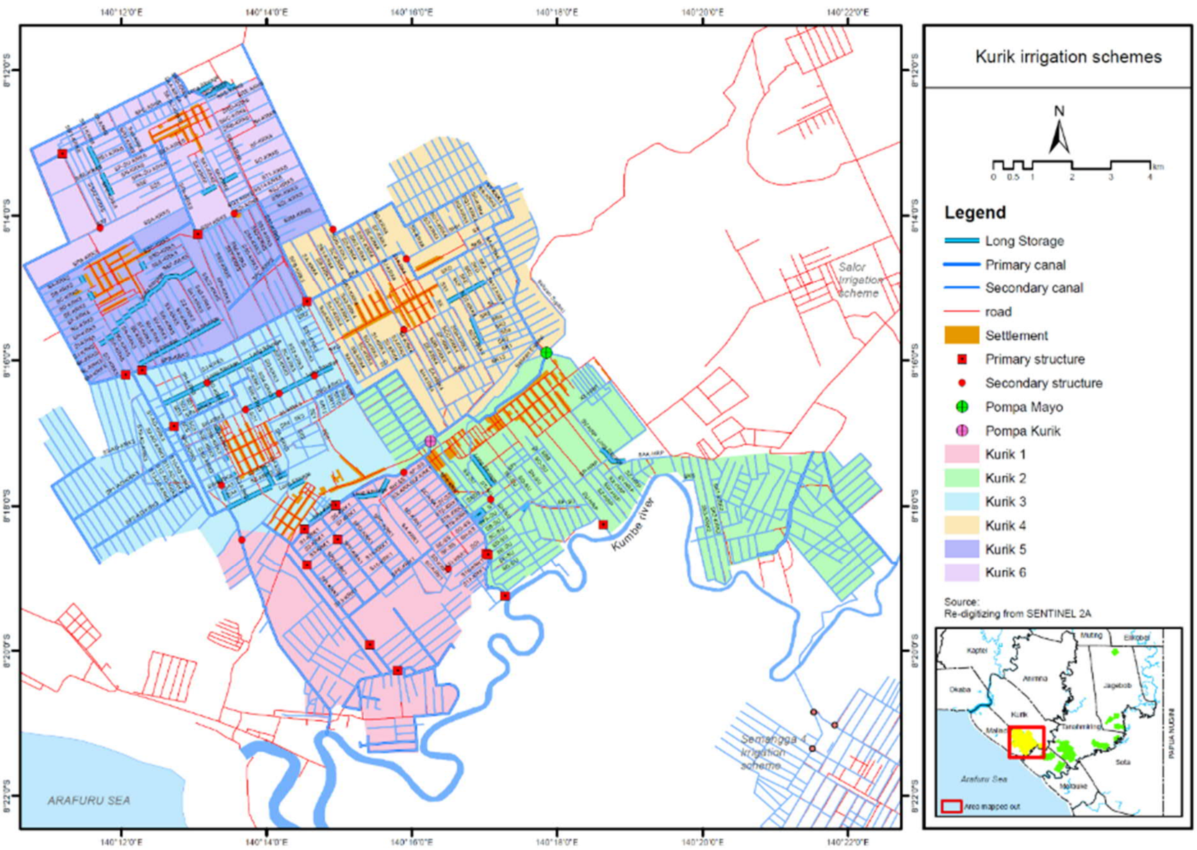
Table 1-2 Kurik lowland irrigation scheme unit

Item		Kurik I	Kurik II	Kurik III	Kurik IV	Kurik V	Kurik VI	Total Kurik
Kampung/Village		Rawasari	Harapan Makmur	Padang Raharja	Jaya Makmur	Suka Maju	Sumber Mulia	
Area	ha	1,500	1,200	950	1,600	1,500	850	7,600
Primary Structures	Unit	9	-	1	2	-	2	14
Secondary Structures	Unit	2	2	5	3	2	2	16
Primary canal	M'	21,550	-	12,800	2,900	10,300	10,750	58,300
Secondary canal	M'	38,000	52,958	52,302	62,600	65,407	49,840	321,107
Protection dike	M'	3,500	-	4,800	-	4,600	-	12,900
Pond	Unit	-	144	-	-	-	-	144
Water pump	Unit	2	2	-	-	-	-	4
Pump House	Unit	1	1	-	-	-	-	2
Deep well	Unit	-	-	7	-	4	-	11

Source : Regulation of the Minister of PUPR Number 14/PRT/M/2015 Year 2015
Notes 1): Jaya Makmur area of cultivation measured at 2885 ha and suggests that areas have been extended since initial design.

The layout of the Kurik Scheme is shown with the two pump stations and the reservoir shown although the satellite images rarely show any water in the reservoir. Detailed layouts of the scheme are in 6 parts associated with the individual settlements with canals referenced and shown in **Appendix A of the Hydrology Report**, along with details from the condition surveys and proposals for rehabilitation. Key features of the scheme in terms of infrastructure: canals and structures are given on **Table 1-2** The scheme comprises of 6 subprojects based on transmigration units.

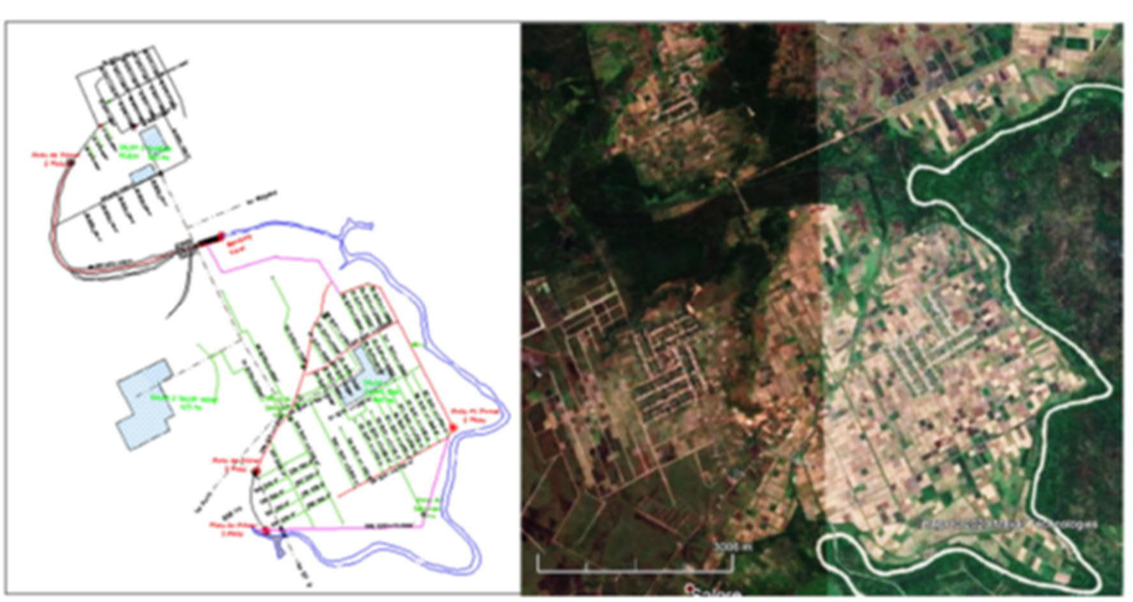
Figure 1-3 Map of Kurik lowland irrigation schemes



1.3.2 Salor lowland irrigation scheme

The Rawa Salor scheme provides irrigation to three villages: Telaga Sari, 950 ha, Salor Indah 425 ha, and Sumber Rejeki, 350 ha. Telaga Sari is the largest and takes water from the Kumbe River with two intake channels and two control structures each with two gates.

Figure 1-4 Map of Salor lowland irrigation schemes



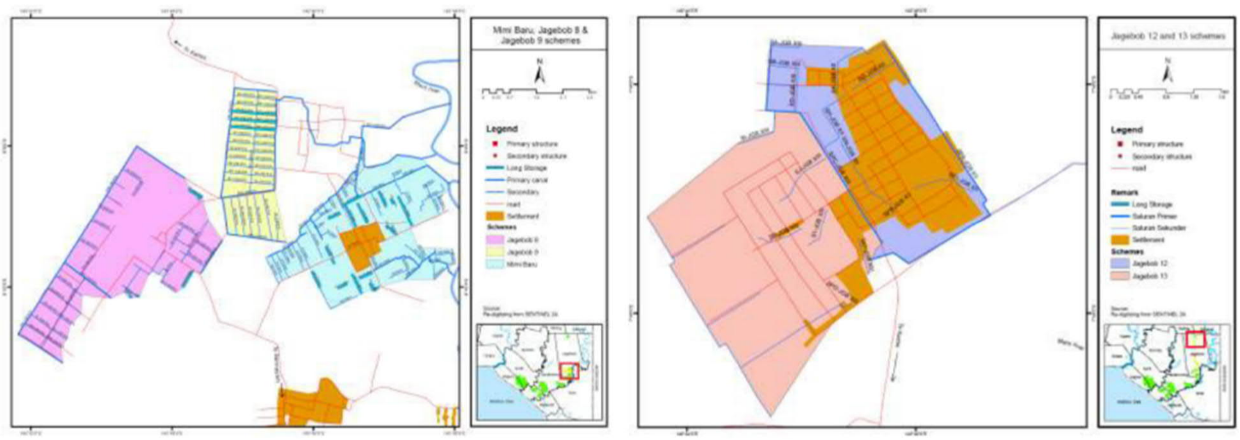
Salor Indah has a link canal from the Telaga Sari system as well as an intake from a swamp drain. The scheme layout shows Sumber Rejeki takes water from a Kumbe river tributary that drains swamp lands via a retention pond with control gates (previously there was a rubber dam) and link canal to Salor 1 scheme. A map of the scheme is shown on **Figure 1-4.**

1.3.3 Jagebob lowland irrigation scheme

Jagebob villages and their cultivated areas are shown on **Figure 1-5** with other upper Maro schemes. From quick observations during the inception period, Jagebob Lowland Irrigation scheme could be described as an 'underperforming scheme' compared with other schemes. According to the O&M field staff from Dinas Pengairan, only about 620 ha is cultivated for one crop per year on about 10% of the owned area that is easily supplied by the river but is also at risk of flooding. The crop has an average yield of only 2 to 3 tons GKP/ha. Many long storages have been excavated around the irrigation area but farmers report that due to early usage, evaporation and permeability they quickly dry out. The higher topography makes pumping from the river essential, but the farmers cannot afford pumps and fuel.

The low soil fertility and suitability for rice cultivation are additional limiting factors on farm productivity. The SKI land classification system for Jagebob is described as gently undulating old coastal plain; slope 2-8%; sub-recent and recent mixed riverine alluvium. Compared to land to the south a physiographical description would be as 'upland' with soils in this area found to be 'whitish' indicating a low fertility and mixed with reddish pebbles that are seen in the dried canals.

Figure 1-5 Map of Jagebob Lowland Irrigation Schemes



1.3.4 Sermayam lowland irrigation scheme

Sermayam lowland irrigation scheme is just south of Jagebob District, see **Table 1-3**. The area comprises 4 sub schemes with a total area of 4,400 ha as shown below.

Sermayam 1 and 2 are both shown on **Figure 1-6** but in the fact are separated by about 1.6 km. They are in a particularly active reach of the river that has many oxbows and evidence of many previous channels. Closer to this disturbed area is the Rawa Erom that appears productive, however a large area to the east of Rawa Erom is an abandoned swamp scheme covering some 650 ha. The lower Jagebob clusters of Agrindo and Kamnosari are part of Rawa Agrindo which is classed under Daerah Irigasi Rawa Sermayam and shown on **Figure 1-7** with several intakes from the Maro River.

Table 1-3 Sermayam Lowland Irrigation Scheme

Item		SERMAYAM				Total Sermayam
		Sermayam 1	Sermayam 2	Erom	Agrindo	
Kampung/Village		Sermayam 1	Ngguti Bob	Erom	Kamnosari	
Area	ha	1,100	1,400	1,000	900	4,400
Primary Structures	Unit	1	3	3	1	8
Secondary Structures	Unit	-	-	-	2	2
Primary canal	M'	113,230	15,050	10,080	6,750	145,110
Secondary canal	M'	39,193	30,392	33,800	27,140	130,525
Protection dike	M'	-	-	-	-	-
Pond	Unit	-	-	-	-	-
Water pump	Unit	-	-	-	-	-
Pump House	Unit	-	-	-	-	-
Deep well	Unit	-	-	-	-	-

Source : Regulation of the Minister of PUPR Number 14/PRT/M/2015 Year 2015

Figure 1-6 Map of Sermayam lowland irrigation schemes 1 and 2

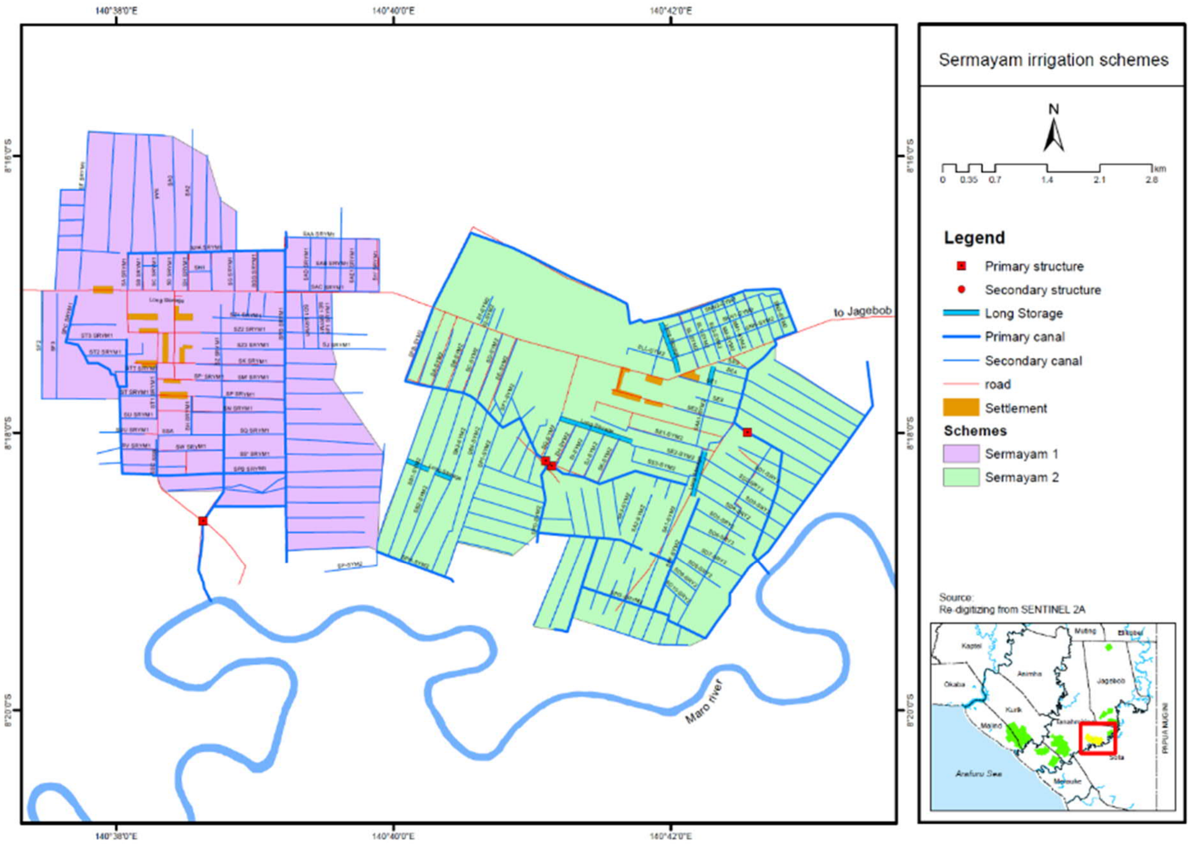
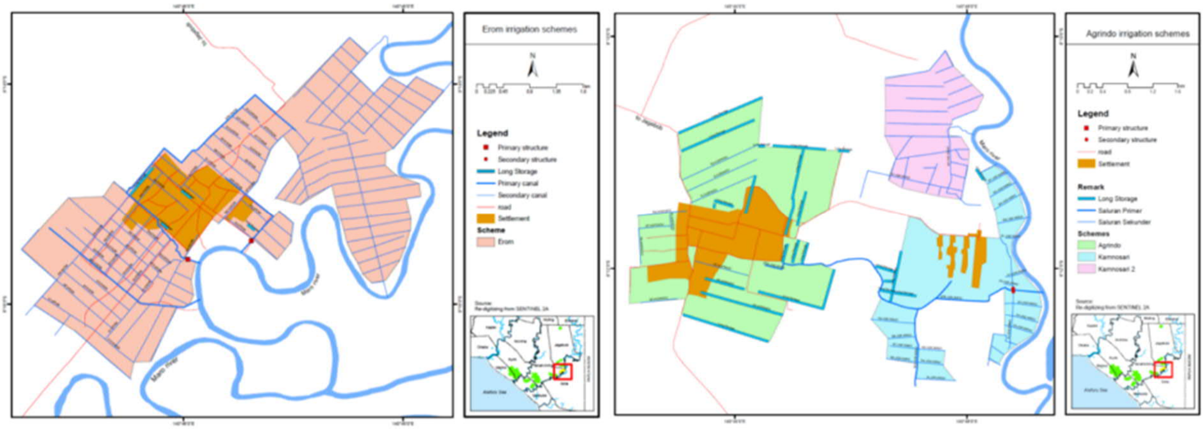


Figure 1-7 Maps of Erom Agrindo and Kamnosari lowland irrigation scheme



1.3.5 Tanah Miring lowland irrigation scheme

The Merauke Consultants visited Tanah Miring scheme in July 2020. The scheme abstracts water from the Maro River via a free intake cut through the bank. An intake channel flows through an overgrown reach of about 350 m from the river to a control structure with 3 sluice gates. It is understood that this initial channel runs through adat land and no agreement has been reached on access for maintenance. Primary canals to the 8 sub-project settlements and farmland branch from this gate. Secondary canals feed from the primaries usually during the wet season by tidal variation although rainfall also contributes. The secondaries are to be filled during the dry season by pumping using diesel driven hand tractors as pumps. The pumps have to be used again to pump into the fields. Pumping with diesel machines is not considered environmentally friendly due to CO2 emissions and we recommend that diesel power should be replaced in future by electric power. In this area farmers already grow a double crop making economic improvement hard to achieve.

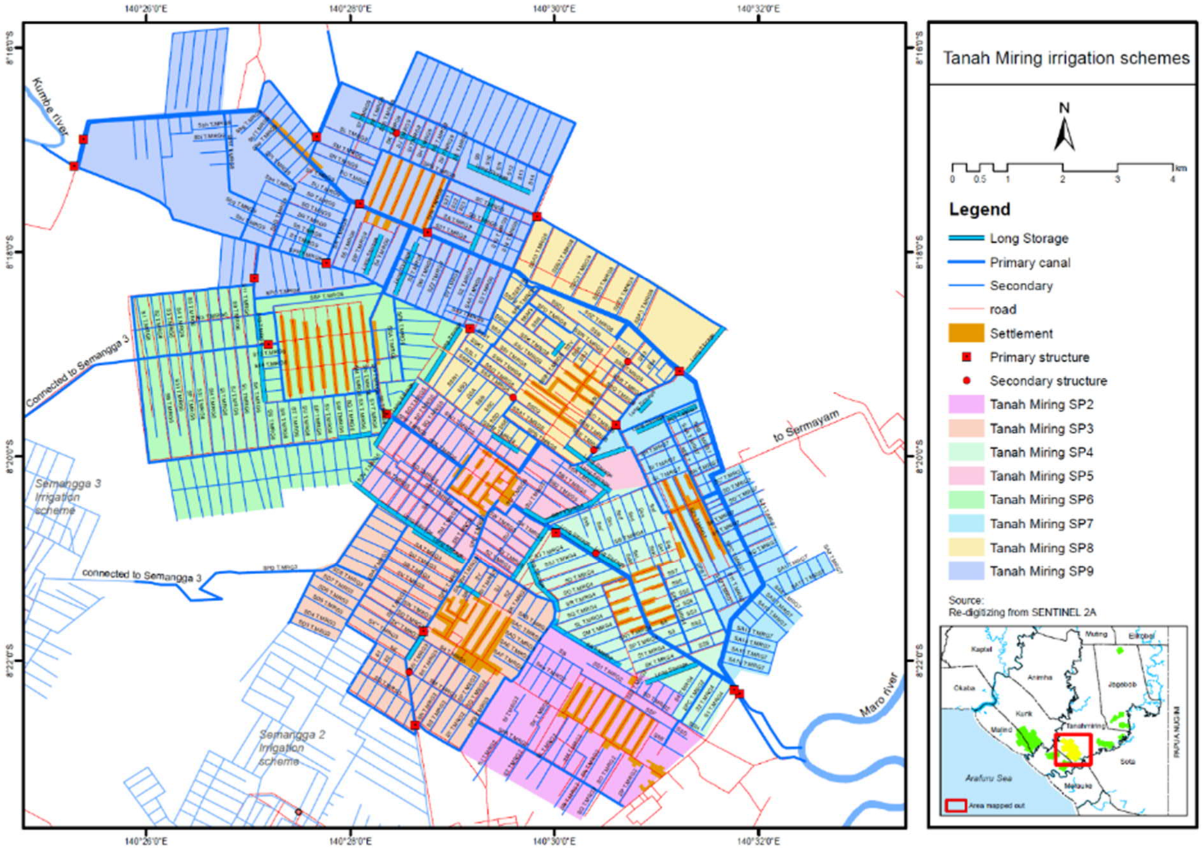
The BWS is developing a pilot scheme in SP5 to modify the secondary canal into long storages. Some rehabilitation works have been carried out in SP3, SP5 and SP8 but work at several other locations, such as the intake channel as mentioned above, cannot be carried out due to issues of customary land ownership. A layout of Tanah Miring is given in **Figure 1-8.**

Table 1-4 Tanah Miring lowland irrigation scheme

Item		TANAH MIRING								Total Tanah Miring
		SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9	
Kampung/Village		Jasa Mulia	Sumber Harapan			Isano Bias		Amun Kai		
Area	ha	540	900	1,000	1,000	1,300	600	1,000	1,500	7,840
Primary Structures	Unit	-	2	1	1	3	1	3	7	18
Secondary Structures	Unit	-	1	1	-	-	-	3	1	6
Primary canal	M'	4,685	17,479	1,650	3,318	7,950	9,773	11,700	15,200	71,755
Secondary canal	M'	19,770	31,470	34,697	36,217	38,870	-	36,351	51,750	249,125
Protection dike	M'	-	-	-	-	9,000	-	-	10,700	19,700
Pond	Unit	-	-	-	-	-	-	-		-
Water pump	Unit	-	-	-	-	-	-	-		-
Pump House	Unit	-	-	-	-	-	-	-		-
Deep well	Unit	-	-	-	6	-	-	9		15

Source : Regulation of the Minister of PUPR Number 14/PRT/M/2015 Year 2015

Figure 1-8 Map of Tanah Miring lowland irrigation scheme



1.3.6 Semangga Lowland Irrigation scheme

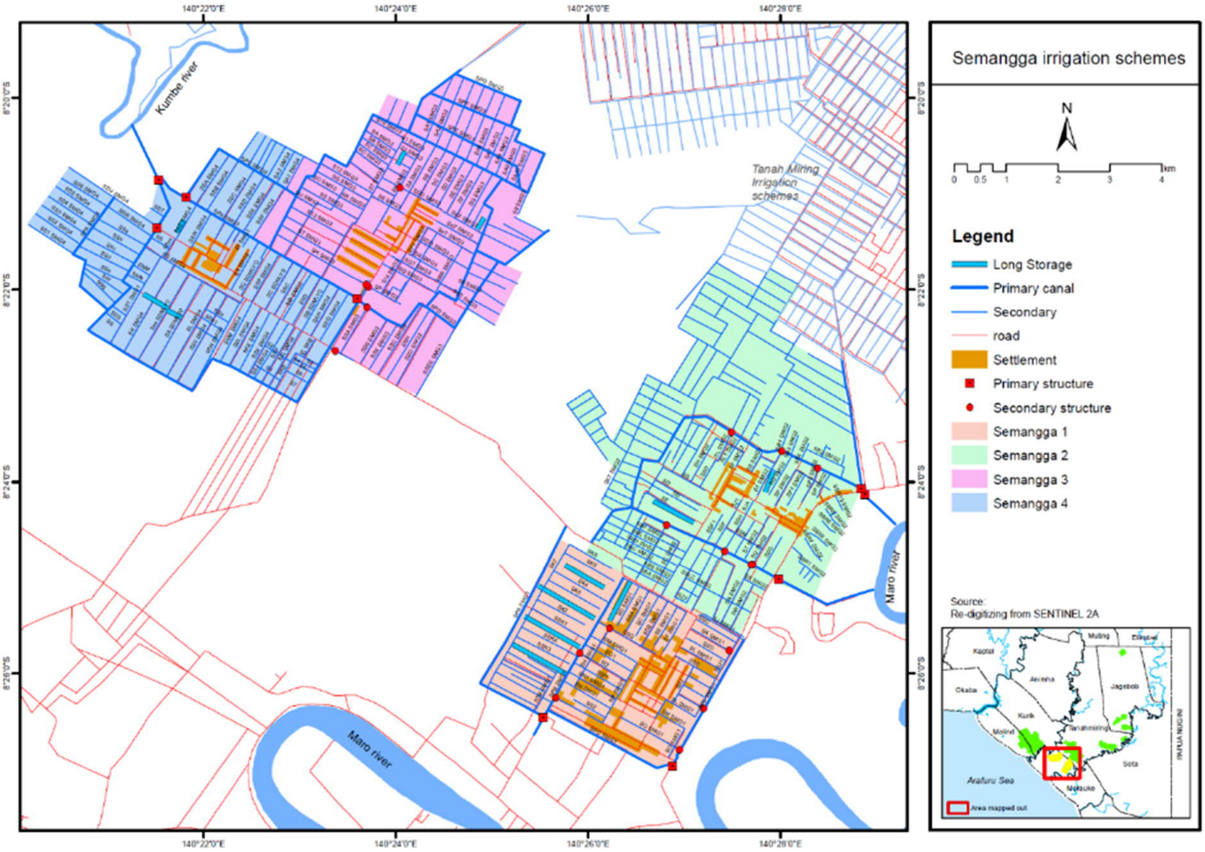
Semangga Lowland Irrigation scheme is sited between Tanah Miring scheme and the coast in the form of four units on the higher land areas comprising sediment deposits from the Maro River for Semangga 1 and 2 units and from Kumbe for units 3 and 4. The land between these units is lower lying, subject to flooding and has not been developed. Units 1 and 2 derive their water from the Maro River whilst units 3 and 4 obtain theirs from the Kumbe River.

Table 1-5 Semangga lowland irrigation scheme

Item		SEMANGGA				Total Semangga
		SMG 1	SMG 2	SMG 3	SMG 4	
Kampung/Village		Semangga Jaya 1	Marga Mulya	Waninggap Kai	Muram Sari	
Area	ha	1,500	1,250	1,550	1,200	5,500
Primary Structures	Unit	2	3	1	3	9
Secondary Structures	Unit	8	7	5	11	31
Primary canal	M'	12,350	4,200	13,690	4,270	34,510
Secondary canal	M'	36,741	60,925	68,910	70,535	237,111
Protection dike	M'	-	8,700	7,400	9,750	25,850
Pond	Unit	4	1	-	-	5
Water pump	Unit	-	-	-	-	-
Pump House	Unit	-	-	-	-	-
Deep well	Unit	7	6	4	8	25

Source : Regulation of the Minister of PUPR Number 14/PRT/M/2015 Year 2015

Figure 1-9 Map of Semangga lowland irrigation scheme



At present the farmers say the water only becomes saline during the dry season usually after their second crop. They will be subject to saline inundation more frequently in the future especially when rare events such as cyclonic storms in the Arafura Sea create tidal surges when combined with high tides. Details of the units are given below with a layout based on the BIG (Bakosurtanal) 1:50,000 maps on **Figure 1-9.**

1.4 Existing lowland irrigation schemes managed by the Provincial Government

The Provincial Water Resources Service (PSDA) has a responsibility to manage the lowland irrigation area with the size more than 1000 ha, but less than 3,000 ha. Information collected during the visit of the Merauke Consultants concluded that there are five lowland irrigation area covering 8,460 ha managed by the Provincial Government. Those are Serapu, Kuprik Sidomulyo, Salor, Wasur and Okaba.

Table 1-6 Lowland irrigation schemes managed by the Provincial Government

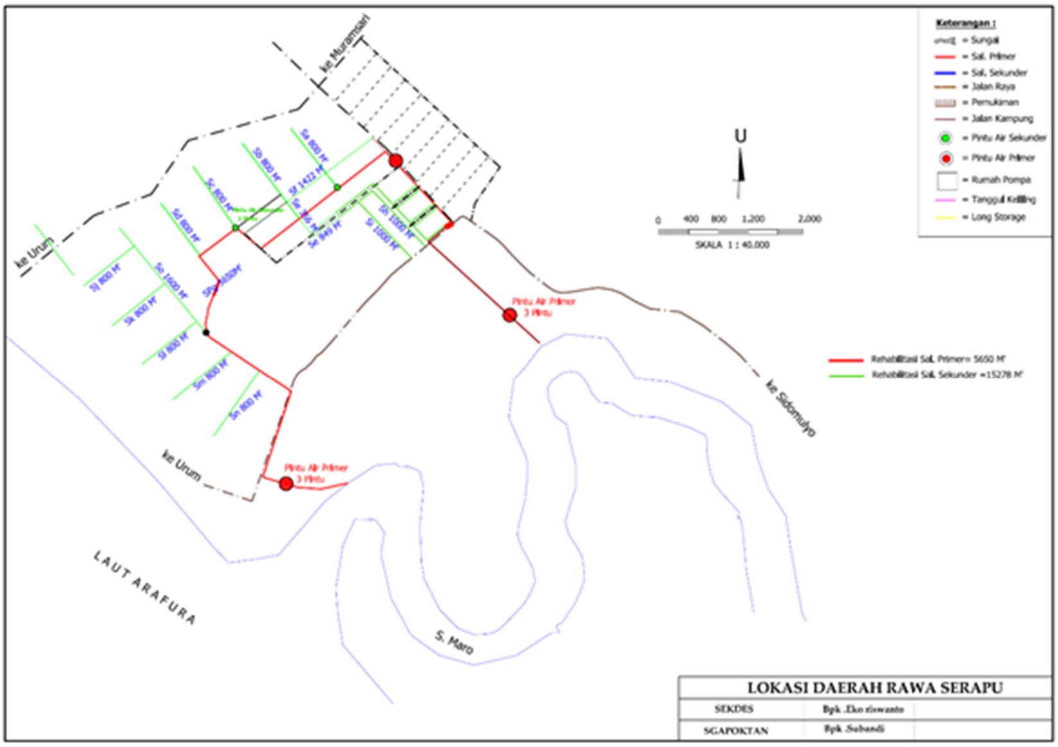
No.	Scheme name	Village	Area (ha)	Source of water & notes
1	Serapu	Serapu	1,400	Maro
2	Kuprik Sidomulyo	Kuprik/Kuper/Sidamulyo	1,600	Maro
3	Rawa Salor	Telaga Sari		Kumbe
		Salor Indah	2,460	Kumbe
		Sumber Rejeki		Tributary of Kumbe
4	Wasur Nasem	Wasur	1,500	Tributary of Maro, N Merauke
5	Rawa Okaba	Industrial proposal	1,500	Only small stream at site

1.4.1 Serapu lowland irrigation scheme

This scheme is close to the Maro Estuary on the western bank. For a limited habitation area, it covers a large area of cultivation, can be seen at **Figure 1-10.**

Perhaps some of the farmers live in Merauke on the opposite bank. It is assumed that dry season flows will be brackish and that strategies to either reduce the salinity of the water or plant more saline tolerant crops would be useful in future. The area is susceptible to high tides and storm surges as it is only 4-6 m above sea level.

Figure 1-10 Map of Serapu lowland irrigation scheme



1.4.2 Kuprik Sidomulyo lowland irrigation scheme

This Kuprik Sidomulyo lowland irrigation scheme is also close to the Maro Estuary on the eastern bank about 6 km further upstream than the Serapu lowland irrigation scheme.

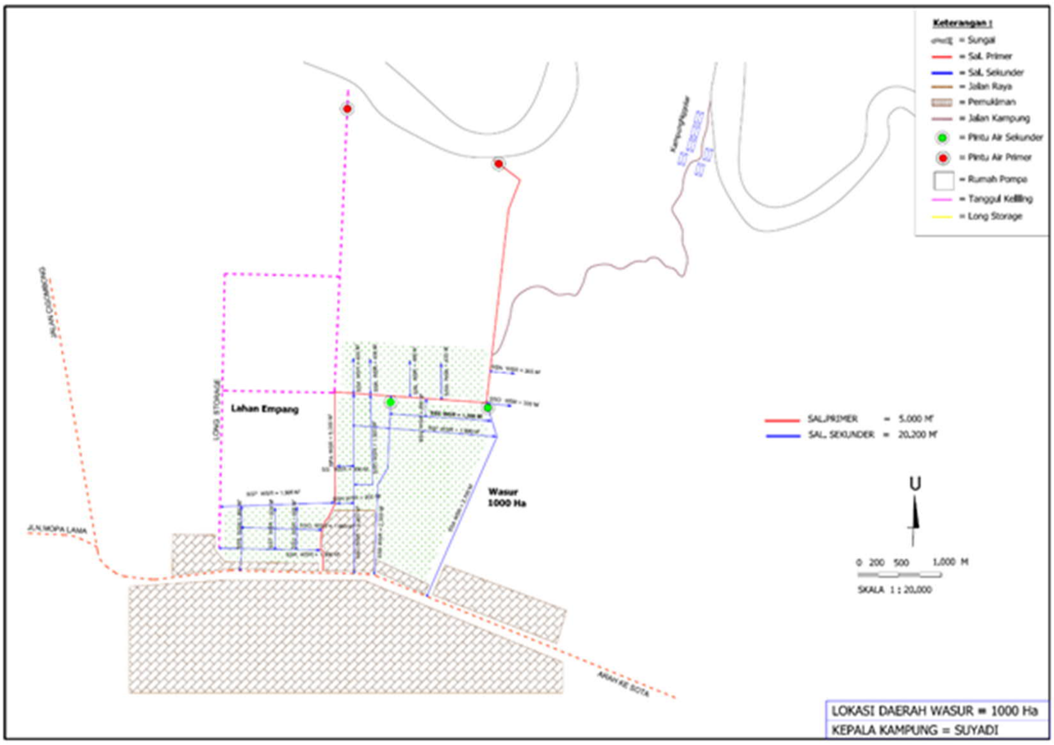
Kuprik Sidomulyo Scheme also has similar salinity problems but at the same time can be operated by tidal irrigation during the wet season. Generally, the farmers cultivate their land two times a year, but the second crops suffer from saline water. Close by is about 1,900 ha of swamp that has had drainage channels cut through but is unutilised. It is shown on **Figure 1-11** in relation to the Maro Estuary.

Figure 1-11 Kuprik Sidomulyo lowland irrigation scheme

1.4.3 Wasur lowland irrigation scheme

Rawa Wasur scheme is also shown in location on **Figure 1-12** near the Maro Estuary but on the East bank just north of Merauke City. It would appear to have a target of 1,000 ha to be cultivated than an estimate of the actual farmed area. Except for a small area cultivated by the Wasur village most of the area is abandoned swamp and has a network of drains cut into it. Only this small area is close to the area set aside for conservation and little interest appears to have been shown in developing it.

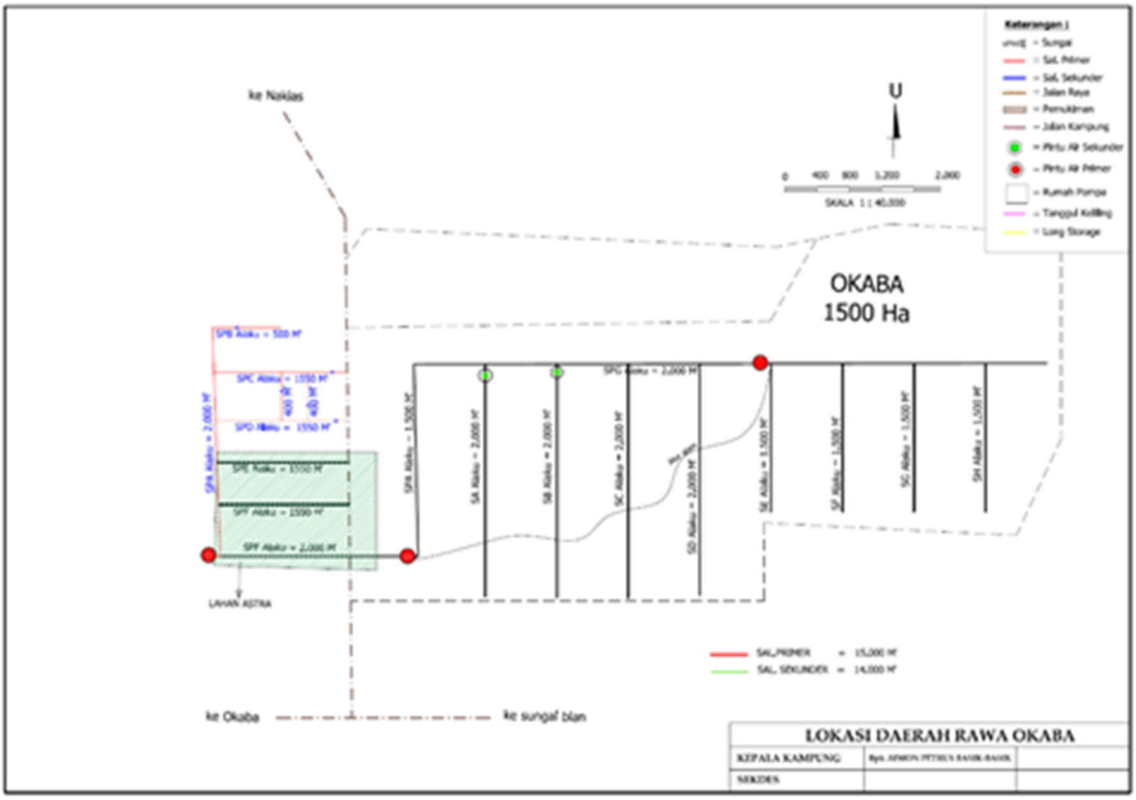
Figure 1-12 Map of Wasur lowland irrigation scheme



1.4.4 Okaba lowland irrigation schemes

The Okaba schemes some parts appear to be for an industrial farming proposal as the map shows a rectangular network of drainage channels assigned to different developers. The scheme is 10 km at its nearest point to the small settlement of Okaba that does have a nearby stream and some 200 houses and a far more promising location to develop an irrigation scheme. The small stream that runs through the site is an upstream part of the possible supply for Okaba, but this would provide only a small flow for such an extensive area.

Figure 1-13 Okaba lowland irrigation scheme



1.5 Existing lowland irrigation schemes managed by the District Government

The Government of Merauke has the responsibility to manage at least 33 lowland irrigation schemes which are 1000 ha in size or less. The areas are distributed over 10 sub-districts.

Table 1-7 Lowland irrigation schemes under Kabupaten Merauke

No.	Name of scheme	Area (ha)	Location / Sub-district	No.	Name of scheme	Area (ha)	Location / Sub-district
1	DIR Alaku	6	Okaba	18	DIR Gurinda Jaya	225	Jagebob
2	DIR Alatep	5	Okaba	19	DIR Jemunaim Jaya	79	Jagebob
3	DIR Sanggase	80	Okaba	20	DIR Kamnosari	156	Jagebob
4	DIR Domande	76	Malind	21	DIR Melim Megikar	131	Jagebob
5	DIR Onggari	120	Malind	22	DIR Mimi Baru	264	Jagebob
6	DIR Kaiburse	67	Malind	23	DIR Nalkin	79	Jagebob
7	DIR Kumbe	306	Malind	24	DIR Obattrow	99	Jagebob

No.	Name of scheme	Area (ha)	Location / Sub-district	No.	Name of scheme	Area (ha)	Location / Sub-district
8	DIR Matara	21	Semangga	25	DIR Poo	15	Jagebob
9	DIR Waninggap Nanggo	32	Semangga	26	DIR Kaliki	10	Kurik
10	DIR Soa/Senayu	58	Tanah Miring	27	DIR Toray	15	Sota
11	DIR Tambat	51	Tanah Miring	28	DIR Erambu	12	Sota
12	DIR Baad	63	Animha	29	DIR Kweel	24	Elikobel
13	DIR Wayau	28	Animha	30	DIR Bupul Kampung	4	Elikobel
14	DIR Koa	25	Animha	31	DIR Tanas	23	Elikobel
15	DIR Kaiza	15	Animha	32	DIR Waan	10	Muting
16	DIR Zanegi	17	Animha	33	DIR Kolam	10	Muting
17	DIR Blandin Kakayo	71	Jagebob		**Total**	**2,197**	

Those 33 irrigation areas under the responsibility of Merauke District Government. The lowland irrigations mainly are just simple drainage cum storage system, connected to the open water. The drainage canals have two functions: as drainage and also as water conservation. As the size varies from 6 to more than 300 ha, the dimension of the canals also varies greatly; but maybe there is something in common:

- From social economic point of view, those areas cultivated mainly the local people who have started growing rice and field crops along with some more traditional tuber crops.
- The locations are not easy to be accessed, therefore the agriculture input is very limited and expensive.
- Farmers cannot compete in the market as their production costs are higher than on other larger schemes nearby. As a result, farmers are only producing very limited yield for their own consumption.
- Some part of the area rent to other farmers outside.
- Many of the farmers are women who grow a variety of organic crops around their household areas.

1.6 Masterplan and Feasibility Study stage

1.6.1 Masterplan stage

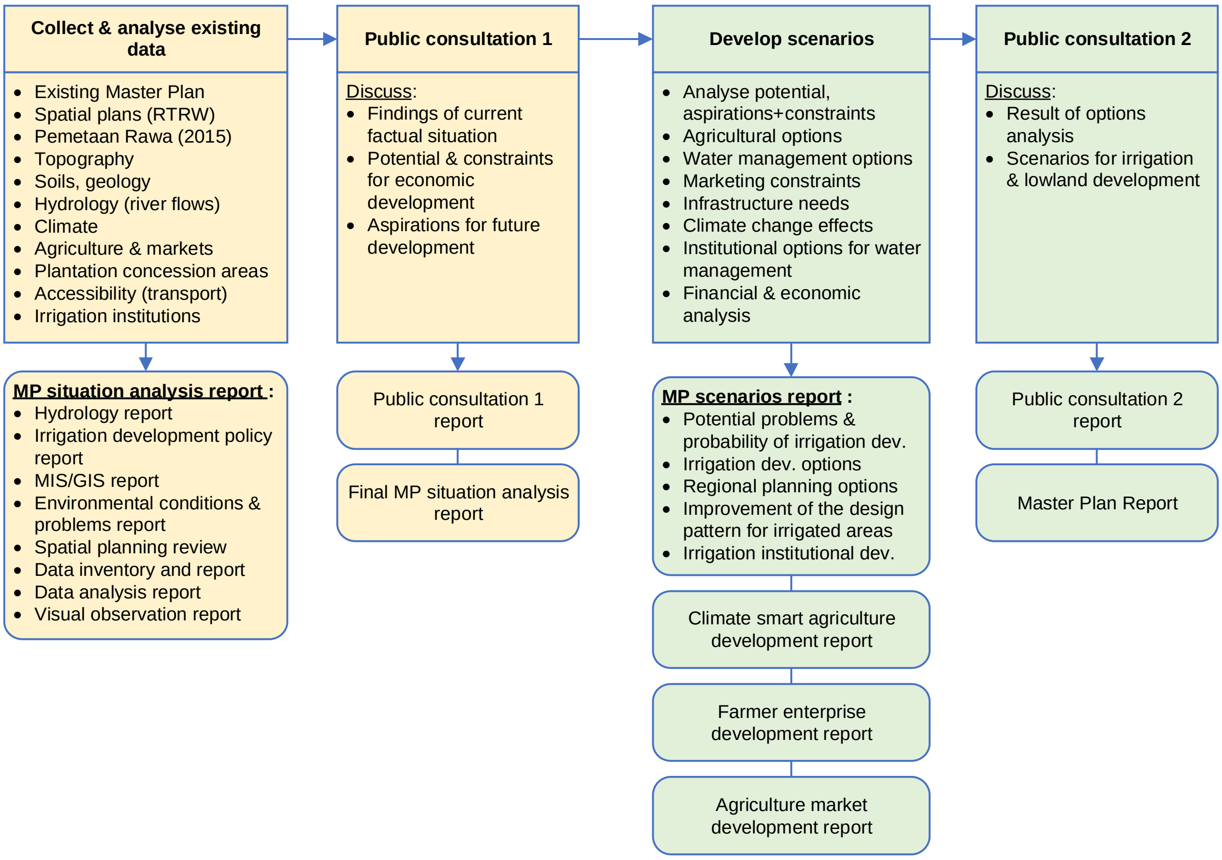
The overall aim of the project *Development of Merauke Irrigation System Phase-1* ("Merauke Irrigation Project") is to assist the Directorate of Irrigation and Lowland, Directorate General of Water Resources (DGWR), Ministry of Public Works and Housing (MPWH) to develop planning activities and management of irrigation areas in the lowland swamp areas of Merauke District. This is to be done in a thorough, integrated and environmentally sound way, and to contribute to sustainable national food resilience. The scope of the services is to prepare (i) a comprehensive Master Plan (750,000 ha) for low-land irrigated agriculture development, covering low-land irrigation infrastructure development, smart agriculture development, and agriculture market development; (ii) a Feasibility Study (200,000 ha) that covers water resources and irrigation, but also infrastructure, institutional, social and environment, agriculture and access to market aspects; (iii) detailed engineering design (DED) for irrigation and associated infrastructure for an area of 25,000 ha; (iv) social and environmental safeguards including land acquisition process (EIA and LARAP); and (v) preparation of bidding documents. In Phase-2, DED, EIA, LARAP and social safeguards are to be prepared for an additional 25,000 ha.

Prior to working on the actual Master Plan, our TA team has, together with the PIU-DGWR (*Tim Direksi*) and BWS Papua Merauke proposed and agreed on the boundaries of the Master Plan target area of

750,000 ha. According to the TOR the project covers four subdistricts (Semangga, Tanah Miring, Jagebob and Kurik), which together cover 427,228 ha (less than 750,000 ha). In consultation with the Tim Direksi and BWS Papua Merauke we have added parts of other adjacent subdistricts, such as Malind, Animha and Okaba to the Master Plan Study.

The Master Plan study is implemented in two stages: (1) the Master Plan situation analysis (description of existing situation and potentials), and (2) the Master Plan scenarios development (for the next 30 years). The result of each stage is discussed with the key stakeholders in a public consultation meeting (PCM). This process is shown the next **Figure 1-14.**

Figure 1-14 The Master Planning process



Two main scenarios are proposed, each having a scale of investment and their resilience to climate change examined. Scenario 2 includes four strategies, three with different approaches to providing irrigation water and one suggesting pilot schemes to test innovative approaches with later widespread interventions. Our TA team studied a third scenario for large irrigation schemes proposed in the RTRW but considered these areas unfeasible as the soils are not highly or moderately suitable and partly on severe upland terrain requiring substantial pumping. Moreover, they would require deforestation, are very remote and isolated, sparsely populated, and there are no existing farmer communities.

Scenario 1: 'Without Project' and relatively low investment starts from the existing situation as the benchmark and predicts what will happen to the existing infrastructure and a modest expansion of irrigated area as already proposed by the different levels of government. The scenario will provide the basis for determining marginal costs and benefits in economic analysis. It includes (i) ongoing projects such as the rehabilitation of BWS schemes; (ii) the future continuation of this project to complete rehabilitation of BWS managed schemes; (iii) the BWS and Provincial government plans for new swamp scheme development and other contracts where readiness actions such as DED, EIE and LARAP might be completed. Scenario-1 will generally reflect an unprepared approach to climate resilience and a reactive approach to flood risk management.

Scenario 2: "With Project" requires medium to high investment with several strategies to consider. It aims to enhance existing smallholder wellbeing by ethnically balanced development. It will incorporate innovative concepts such as upgrading the current simple (*sederhana*) lowland irrigation schemes to more technical status, introducing micro-irrigation to home yard areas.

For Scenario-2, we studied several different irrigation strategies of complementary options, such as: (i) Strategy 1, smaller pump schemes would supply water directly from the river or from the retention ponds /drainage canals, (ii) .Strategy 2, multipurpose river headworks that supply existing and new schemes either by pumping, or by gravity, for example, a low dam or a free intake on the Kumbe River or a free intake on the Maro River, (iii) Strategy 3 looks at other water sources, such as water stored in existing swamps, small dams and oxbow lakes.

The Scenario 2 proposal sets out a possible irrigation development area of some 82,000 ha, which the consultants consider an already ambitious target for the next 20 years. Scenario-2 could benefit from financial support from an international lending agency to carry out a feasibility study on a Kumbe low dam during Phase 1.

1.6.2 Feasibility study

The objective of the Feasibility Study is to prepare preliminary irrigation layouts and concept designs for 50,000 ha (25,000 ha Phase-I, and 25,000 ha Phase 2) within the 200,000 ha included in the feasibility study, including TORs for conducting EIA and LARAP for the targeted Phase 1 area.

To succeed in developing productive and commercially successful irrigation systems in Merauke, an integrated approach is required. After all, the development of the lowland irrigation systems will increase the surplus of agricultural production, and this surplus is intended to be exported to other parts of Eastern Indonesia (other parts of Papua, NTT, etc.) and must be competitive in the local markets of these regions. The ESP project shall thus address shortcomings in the current agricultural production system, post-harvest handling and marketing, and also address local issues, such as balanced development of transmigrant and local Papuan farmers, land tenure (customary land/ *tanah adat*) and climate change.

Addressing these multiple issues requires a multi-sectoral approach, with main elements: (i) improved irrigation, drainage and flood protection facilities, (ii) improved water management, (iii) improved agricultural practices, (iv) improved post-harvest handling, and (v) market development.

Table 1-8 Assessment of possible irrigation areas for feasibility consideration

Ref	Scheme/Area	Area (ha)	Recommended	Uncertain	Rejected
1	Maro-Kumbe area	60,000	60,000		
2	Kumbe Right Bank	36,000	36,000		
3	Malind-Kurik Extension	28,000	5,000	23,000	
4	Mid Jagebob	2,015	2,015		
5	Upper Jagebob	2,406	2,406		
7	Bian high dam/intake	65,000			65,000
8	Upper Maro Scheme	15,000			15,000
	Totals	**213,721**	**105,721**	**23,000**	**85,000**

A major characteristic of irrigation schemes in Merauke District is that cultivation and irrigation is centred around some 60 settlement areas with some sharing the same water supply. To ease planning activities, they have been amalgamated into natural clusters of adjacent settlements. To assist in identifying whether subprojects were suitable for subjecting to feasibility analysis a multi-criteria analysis (MCA) was made utilising criteria for readiness, water resources, agriculture, irrigation, social and environmental aspects, and strategic planning. The process is described in the Irrigation Options Report and the Master Plan Scenarios Report with some twenty subprojects identified as being suitable for investment. In regard to the 200,000 ha of areas described by the ToR for consideration the results of the analysis are summarised in **Table 1-9** below.

The assessment shows that 105,721 ha could be suitable for investment with the top 25,000 ha implemented in a 5-year Phase 1 and the next priority group of 25,000 ha implemented in Phase 2. It is noted that this includes some 28,000 ha of schemes recently subjected to feasibility reports and rehabilitation that are generally included in a third phase of planning for upgrading. It also includes the gross areas of intermediate areas between settlements which includes some areas of protected and other forestry that will be excluded from the net areas.

In addition, the BWS requested that a new irrigation scheme called Rawa Burung covering 5,000 ha be included. As this is partially forested savannah and partly swamp area with no existing farmers it did not score well in the MCA and has been deferred to phase-4. This area would also be covered by the Kumbe left bank scheme should that subproject go ahead.

Two large schemes to be supplied from the Bian and upper Maro rivers were rejected as explained in the Master Plan Scenarios Report with detailed descriptions and explanations in the Appendices. The Bian scheme will be excessively expensive in terms of water supply, requiring a dam 100 km upstream and a 85 km long transmission canal. As an alternative, a river intake was conceived with a wet season reservoir for dry season use owing to high river salinity. As the highest land is at 42 mOD, it would require excessive pumping costs. The service area is on undulating and marginally suitable soils requiring the main canal to be aligned on the ridge that goes into a forest concession. The potential irrigation area is still forested and has no farmers. The Upper Maro Scheme was shown to have some soils moderately suited to rice but there are no farmers, much is covered by forest or swamp forest and access is difficult.

Details of the schemes selected by the MCA are given in **Table 1-9.** The purpose of the Feasibility Study is to select schemes for first and second phases of implementation each covering 25,000 ha.

The Master Plan studies showed that some 36,000 ha could be irrigated from the Maro River flows and 24,000 ha from the Kumbe River following upgrading to fully technical schemes. A proposed future dam on the Kumbe River could extend the current area irrigated by run-of-river flows to 64,000 ha owing to the large potential storage capacity. However, insufficient accurate upstream topographic data precludes this scheme being fully studied during the Master Plan Stage. It is therefore recommended to:

1. Carry out feasibility studies of possible schemes for Phase 1 covering 25,000 ha selected from the most promising schemes from the MCA. There would be two possible water source arrangements: from smaller individual subprojects using the many existing intakes and pumping covering 25,000 ha, or the areas adjacent to the Maro River right bank irrigated from a large Maro Intake that would eventually command some 36,000 ha.
2. Initially prepare the Phase II schemes covering about 25,000 ha in a second phase based approximately on MCA scores. At the same time carry out feasibilities on a Kumbe Dam that could eventually irrigate some 64,000 ha and an alternative of regulating water in the Keramati Swamp that could irrigate some 12,000 ha when augmented from Kumbe excess wet season flows to combine with Kumbe run-of-river offtakes to irrigate some 36,000 ha.

Table 1-9 Schemes with the highest ranking in the MCA

No	Scheme name	Water supply	District	Villages	OAP / Transmigrant	Status Existing / New	Net Area N1 (ha)	MCA Score	Select for FS
1	Salor Secondary PS1	River Pumping	Kurik	Telaga sari, Harapan Makmur, Salor Indah, Candra Jaya	Transmigrant	Existing	5.224	50	Yes
2	Erom PS1 Existing	River Pumping	Jagebob	Bersehati	Transmigrant	Existing	1.521	48	Yes
3	Lower Jagebob PS 1	River Pumping	Jagebob	Kamnosari, Gurinda jaya, Mimibaru, Jagebob Raya, Wenda asri	Transmigrant	Existing	2.296	48	Yes
4	Middle Jagebob small dam	Dam / Small Dam	Jagebob	Kampung Poo, Angger Pamegi, Kartini, Makartijaya, Naikin	Transmigrant & OAP	Existing	2.138	47	Yes
5	Sidomulyo PS1 Main	River Pumping	Semangga	Kuper, Kuprik, Semangga Jaya, Sidomulyo, Urumb	Transmigrant & OAP	Existing	2.304	47	Yes
6	Tanah Miring SP2,4,7 PS1	River Pumping	Tanah miring	Yasa Mulya, Hidup baru, Waninggap Say	Transmigrant	Existing	3.007	46	Yes
7	Kurik 5 and 6 PS2 from Mayo	Swamp Pumping	Kurik & Malind	Sumbermulya, Sukamaju	Transmigrant	Existing	4.200	44	Yes
8	Tanah Miring SP9 PS1	River Pumping	Tanah miring	Yabamaru	Transmigrant	Existing	2.500	44	Yes
9	Kurik 2 PS1	River Pumping	Kurik	Kurik	Transmigrant & OAP	Existing	3.378	43	Yes
10	Kurik 1 PS1	River Pumping	Kurik & Malind	Kurik	Transmigrant & OAP	Existing	2.932	42	Yes
11	Serapu PS1 Main	River Pumping	Semangga	Matara, Urumb, Waninggap Nanggo	OAP	Existing	3.962	42	Yes
12	Upper Jagebob Small dam	Dam / Small Dam	Jagebob	Blandinkakayo, Melinmegikar, Jamunaenjaya, Obathrow	Transmigrant & OAP	Existing	2.406	42	Yes
13	Semangga New area PS1	River Pumping	Semangga	Matara, Waninggap Nanggo, Muram Sari	Transmigrant & OAP	New	5.320	41	Yes
14	Tanah Miring New PS1	River Pumping	Tanah Miring	Yabamaru, Isano Mbias	Transmigrant	New	3.667	41	Yes
15	Salor PS 1 New	River Pumping	Kurik	Ivimahad	Transmigrant & OAP	New	2.437	40	Yes
16	Semangga Central New PS1	River Pumping	Semangga	Waninggap Kai, Marga Mulya, Semangga Jaya, Muram Sari, Urumb, Waninggap Nanggo	Transmigrant & OAP	New	6.042	40	Yes
17	Kumbe PS1	River Pumping	Malind	Kumbe	OAP	Existing	592	38	Yes
18	Sermayam PS2 New system	Swamp Pumping	Tanah miring	Tambat, Kamangi	OAP	New	4.150	38	Yes
19	Malind-Kurik Extension , various sources	Swamp Pumping	Malind	Dumande	OAP	New	26.173	28	Yes
20	Rawa Burung	River pumping	Kumbe pumping	Tanah Miring 9	Transmigrant	New	5.000		
						Subtotal	**89.250**		
15	Kumbe barrage	Weir / Barrage	Tanah miring	All	Both	New	64.000	44	For PFS

Notes: What is meant by pumping is an effort to provide water through a supply system. But basically, the fulfilment of water needs about 75% of the water is done by farmers themselves by pumping directly from draining channels / conservation ponds. Only about 25% of the water is provided with a supply system with a pump in the giving channel.

1.7 Previous studies and design

1.7.1 Water resources strategic plan (POLA) for Einlanden-Digul-Bikuma watershed

Pola of BWS Papua Merauke is a part of Pola Pengelolaan Sumber Daya Air Einlanden – Digul - BIKUMA River Basin. According to the Presidential Decree No. 12 of 2012 that WS Einlanden-Digul-Bikuma consists of 29 river basins. Generally, the condition of the entire watersheds is relatively well maintained. There is 67% forest covering to all river areas included swamps, shrubs and the rest of 23% for savanna. The potential of those river basins is huge. However, it has not been sufficiently utilized due to the flat topography which causes sea water intrusion coming into the upstream of the rivers when the dry season comes.

The Indonesia government has a plan to manifest the national food self-sufficiency. It is used as the basis and consideration of the province Government of Papua to strive for its implementations. According to the "***Masterplan Percepatan dan Perluasan Ekonomi Indonesia*** **(MP3EI)**" or The Acceleration and Expansion of Indonesia's Economy Master Plan whereas the main purpose is the development of the Papua-Maluku as the corridor National of Centre for Food, Fisheries, Energy and Mining Development.

MIFEE program

The MIFEE (Merauke Integrated Food and Energy Estate) program was launched in 2010 to support the realization of a food development centre in Merauke District. MIFEE was intended to be a supporting program to create new farm fields in the short-, medium-, and long-term (20 years) by allocating the area of 2 million hectares (Merauke District Agriculture Office 2012).

Related *issues*

The Ministry of Public Works and Housing, through the BWS Papua Merauke identified the following issues related to the MIFEE program:

a. Degradation of river water quality

It is due to the mining activities in the upstream area of the river. Several issues of river pollution coming from Fly and Maro River. Both are the crossing-country rivers whose upstream reaches are in the area of Tabobil and Tedi mines. The physical impact for rivers water quality is the high sedimentation that are caused by tailings disposal.

b. Deforestation

The total area of forest area in the Einlanden-Digul-Bikuma is 125,998 km^2 and the MIFEE program covers approximately 1.2 million hectares, of which approximately half is still forested. The MIFEE program will thus reduce the forest area by approximately 600,000 hectares.

c. The agriculture and plantation development plan

MIFEE is the program to make the Merauke District becoming the barn of national and international food and energy in the future. The subdistricts within area of River Basin Einlanden-Digul-Bikuma generally still rely on the agricultural and plantation sectors as the main livelihoods. Therefore, it is necessary to provide supporting infrastructure to escalate the agricultural and plantation production.

d. Local culture

Regarding to this program, the development of water resources infrastructures in the customary territories need to be studied first to avoid disputes regarding to the territories in the future.

e. Cross-country river basins

There are four watersheds as the crossing country-river in the Einlanden-Digul-Bikuma, namely Digul, Maro, Uruci Kondo and one river is the Fly River. Fly river itself is the borderline of Indonesia and Papua New Guinea. As general, the upstream of those watersheds are in Papua New Guinea (PNG) going to Indonesian Territory as the downstream. These can trigger a conflict if they are not handled properly due to the any activities related to the rivers which are carried out in the upstream and could make an impact to the downstream.

One of the issues of river pollution is mining company of Tedi Mine which arose in the Boven Digoel District area. It was indicated by pollutant in the Fly River Bulge tributaries which the river is utilized daily by residents. However, this still needs to be proven by field verification from the relevant agencies of the two countries. (28^{th} JBC Meeting, 2011).

f. Flood, Sedimentation & the beach damage

Flood is the main problem and experienced by districts located in the estuary area of the Einlanden-Digul-Bikuma River Basin. The main cause of flood is the flat topography. This condition is more severe when high tides coming at the same time with rain, therefore the river is unable to accommodate the water. In addition, the high amount of sedimentation reduces the river cross section which heighten the risk of flood.

Moreover, the beach damage is a matter that needs attention as well as the illegal mining of sand beach in the Merauke District that exacerbates the damage to the coastline. Also, those are the problems that need to seriously be handled.

MIFEE development scenarios

The MIFEE program will have a huge impact on water needs in the Einlanden-Digul-Bikuma river basin, the opening the large-scale agricultural and plantation land will require enormous of water resources of more than 90% that will be used by the agricultural and plantation sectors.

Because there is no assurance of the MIFEE program in the future, the anticipated action for the various possibilities that may occur for the sustainability of MIFEE program. Therefore, the several scenarios of meeting water needs were made as follows:

a. In the planning of the MIFEE program, 1.2 million hectares of land were allocated for agriculture and plantations which were divided into ten clusters with the main motor of private investors working on the land. Due to the uncertainty of land allocation for each agricultural and plantation commodity, an assumption of land area is made for calculation purposes.
b. The area of agricultural land in the MIFEE program is set at approximately 250,000 ha to support food security in Papua Province. Meanwhile, the projected area of plantation and land area is in line with the current growth trend.
c. Scenarios for agricultural land growth without the MIFEE program with projections of agricultural land, plantations and fields following the existing growth trend.

To anticipate the increase in water demand in the future, it is necessary to plan efforts to fulfil the water demand node which is predicted to experience water shortages based on the results of the analysis that has been carried out. Efforts made to meet the water shortage are based on the economic growth scenario, namely high, medium and low economic growth.

a. **Low Economic Growth**: Low economic growth assumes that the economic growth of the Einlanden-Digul-Bikuma WS is lower than the national economic growth rate (<4.5% per year). Based on these assumptions, efforts to fulfil water supply for irrigation, households and industry are only carried out to meet urgent water needs based on a priority scale so that it is still unable to meet the overall water demand.
b. **Moderate Economic Growth**: Moderate economic growth is assumed that the economic growth of the Einlanden-Digul-Bikuma WS is the same as the national economic growth rate (4.5-6.5% per year). Based on these assumptions, efforts to fulfil water supply for irrigation, households and industry can be carried out according to the minimum water supply required
c. **High Economic Growth**: In this scenario, it is assumed that the economic growth of the Einlanden-Digul-Bikuma WS is higher than the national economic growth rate (> 6.5% per year), so that it is possible to carry out all planned activities to fulfil water supply for irrigation, households, and industry. carried out in accordance with the required water supply

1.7.2 PUSLITBANG study of the Bian-Kumbe-Maro irrigation area

Food sovereignty is still a challenge for the Indonesian people. Although Indonesia is called an agrarian country where most of the population are farmers, in reality there are still many food shortages in some areas due to the increasing population. During the period 1997-2001, rice productivity decreased by 0.38% per year, also in several food commodities (Food Security Agency, 2006 in the Food Security Council, 2009). This condition must be fulfilled from imports. This is an unfavourable condition because imports drain a lot of foreign exchange and not strategic for the interests of national food security in the long term (Food Security Council, 2009).

Population growth is not the only factor that hinders national food security. Another serious factor is the conversion of agricultural land. This is what causes the number of agricultural productions to decline, plus the climate change factor that causes crop failure in several areas. The total area of paddy fields in Indonesia in 2011 was ± 8.09 million ha, while the rate of land conversion from 2003 to 2007 occurred at a rate of 110 thousand ha/year and it is predicted that 10 years to 2017 the area of land conversion caused by improvements in spatial planning all districts in Indonesia reach 3 million ha of productive land (BPS, 2014).

Food security is one of the focuses of research activities of the PUSLITBANG SDA as stated in the Strategic Research and Development Program of the Ministry of PUPERA 2015-2019. The research activity "Development of Swamp Irrigation Land in Papua" aims to obtain potential locations in Papua that are suitable for development, especially what will be carried out is the extensification of agricultural land.

Agricultural extensification is an effort to expand agricultural areas by opening new land for agriculture. One of the areas that has the potential to be developed is swamp land, where the area of swamp land in

Indonesia reaches ± 33.4 million ha, while the potential area that can be cultivated for agricultural reaches ± 10.2 million ha (Alihamsyah, 2004).

This research activity was carried out in Papua Province, with a potential swamp area for agriculture of ± 2.8 million ha, ranking second after Sumatra at ± 3.9 million ha (Alihamsyah, 2004). Therefore, research activities on Irrigation Development in Papua were carried out to assist stakeholders in obtaining strategic locations that could be developed in support of the food sovereignty program.

In 2018, it produced a report on Swampland Development Technology with an output component of Guidelines (R0) for Preparation of Procedures for the Development of Swamp Irrigation and Design Criteria for Hydraulic Infrastructure Design for Swamp Irrigation Development and Guidelines (R0) for Integrated Long Storage of Swamp Irrigation. The purpose of this activity is to obtain Swamp Land Development Technology in order to support the Government in opening 1 (one) million hectares of agricultural land (nawacita). Meanwhile, the formulation of the problem that forms the basis for making this output is the unavailability of information on the availability and balance of water in the Digoel, Bian, Kumbe, and Maro rivers on potential land and accurate topographic maps.

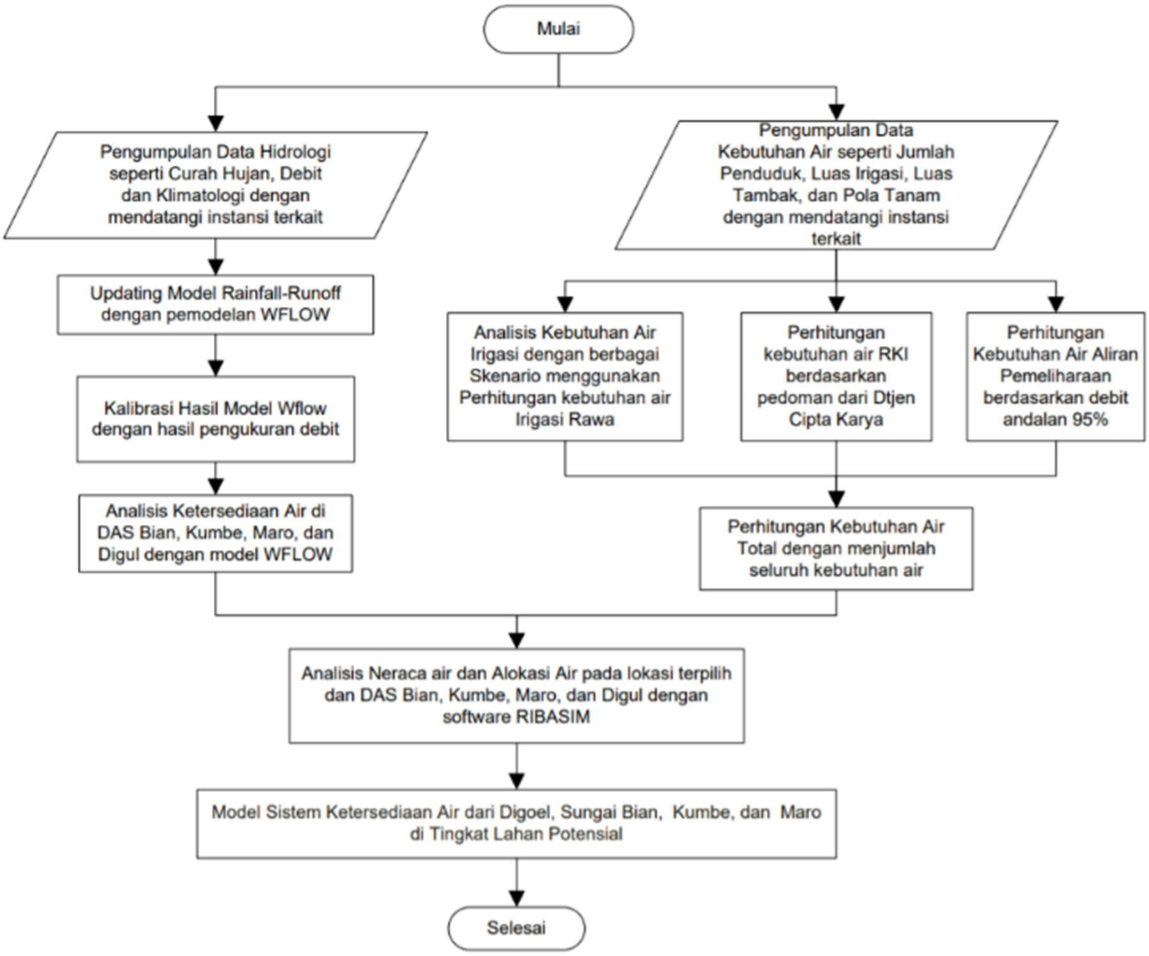
The location for this activity for 2017 was Merauke District, Papua Province, which includes the Bian River, Kumbe River, Maro River, and Digoel River, included engagement of PUSLITBANG SDA in Bandung and the Directorate of Water Resource in Jakarta for technical coordination and discussions. This area was chosen in order to support the President's Nawacita program and the Ministry of PUPR in developing 1 million hectares of land in Prov. Papua.

The activities carried out are included in the integrated applied technology output group to support the Swamp Land Development Technology which is carried out on a multi-year basis and will be produced in 2019. The output component in the 2016 Fiscal Year is 1 (one) Scientific Paper on the Development of Irrigation Land in Papua. In Fiscal Year 2017, this activity will produce 2 (two) output components, namely:

1. *Model Sistem Satuan Lahan, Kesesuaian Lahan, dan Zona Pengelolaan Air pada Lokasi Terpilih*.(Land Unit System Model, Land Suitability, and Water Management Zone at Selected Locations)
2. *Model Sistem Ketersediaan Air dari Sungai Digoel, Sungai Bian, Sungai Kumbe, dan Sungai Maro*. (Water Availability System Model of the Digoel River, Bian River, Kumbe River, and Maro River)

The implementation of the system model design in this study is explained through the flow diagram shown in **Figure 1-15**.

Figure 1-15 System Model Design Flowchart



With limited hydrological data in the form of rainfall and river flow, the corrected rainfall data from the TRMM satellite was used, and with the Wflow model, time series flow rates were calculated. The discharge from the modelling is then calibrated with the discharge from the measurement. The calculated water demand includes DMI, irrigation, and maintenance flow. The water balance is calculated to get the ideal irrigation area to be developed. Water allocation analysis is supported by DSS-RIBASIM software.

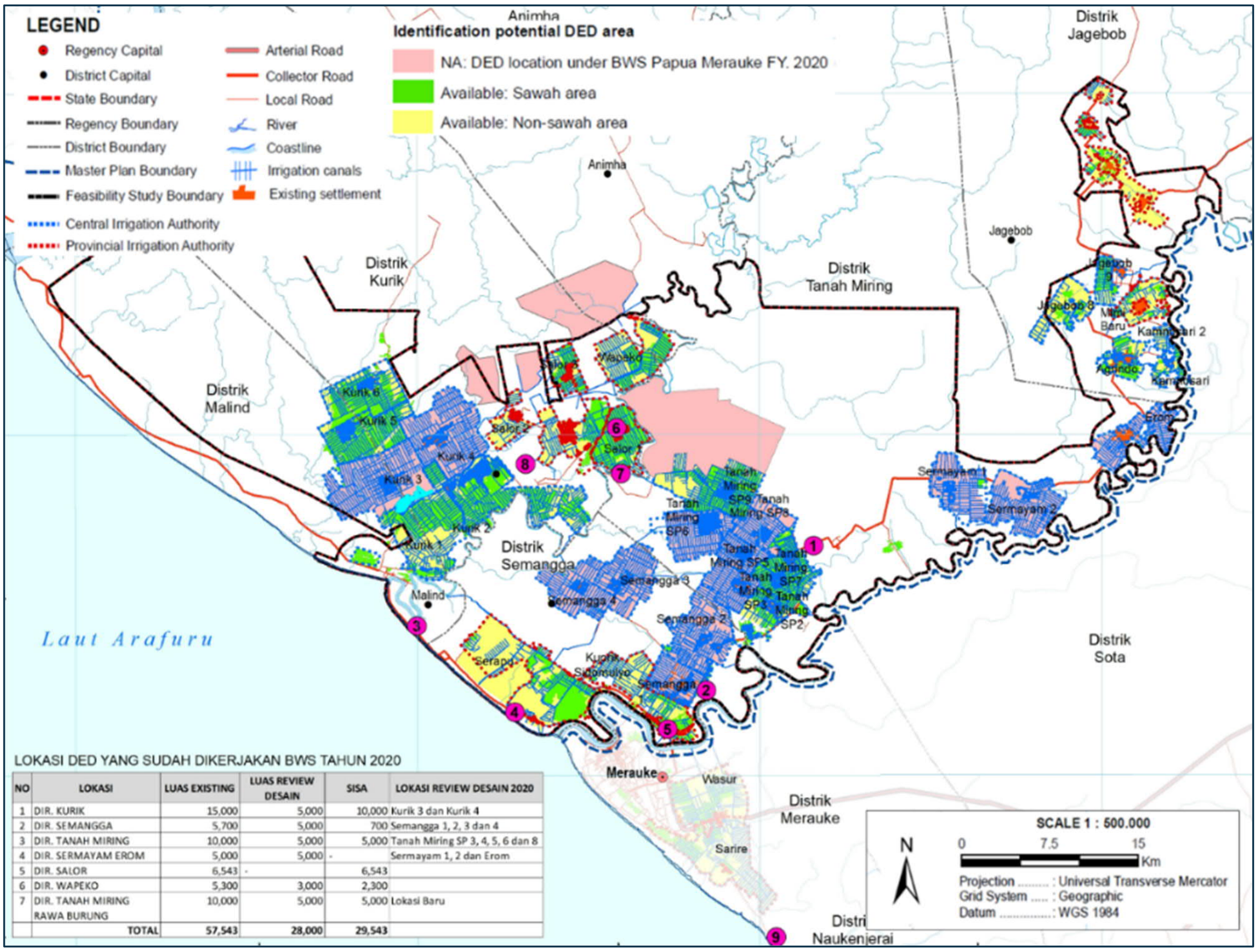
The results of the water balance in the Bian, Kumbe, and Maro watersheds showed that both the rice - rice and rice - palawija cropping patterns experienced a deficit for several months. As for the Digul watershed, because the irrigation area is determined, it experiences a surplus. From this, efforts are needed for the Bian, Kumbe, and Maro watersheds to obtain a surplus water balance. As for the water allocation results obtained in the scenario of the rice - secondary cropping pattern, all Irrigation areas have a success percentage above 80%. Therefore, the cropping pattern in the second growing season to become secondary crops can be an alternative so that irrigation water needs can be met.

There are several solutions in meeting water demand in the Bian, Kumbe, Maro and Digul watersheds, by making rainwater reservoirs or long storage as additional water supply for irrigated lands, setting the beginning of the planting season and cropping patterns, and reducing the irrigation area when other solutions have been implemented but the result is still deficit. What the studies lacked was a social and environmental understanding of local indigenous tensions about transmigrating the large numbers of transmigrant farmers needed from other parts of Indonesia onto traditional forested adat lands used for hunting and gathering.

1.7.3 Existing development plans for Kurik, Semangga, Sermayam, Tanah Miring and Wapeko

The existing larger irrigation schemes are managed by BWS and were the subject of detailed engineering design by local consultants in 2020. From **Figure 1-16** several sub-schemas of existing Irrigation in Merauke District will be rehabilitated as well as some new areas of swampland as indicated by the pink areas. **Table 1-10** below lists the location coverage and irrigation areas whose design review was carried out in 2020.

Figure 1-16 Rehabilitation planning of existing schemes



NO	LOKASI	LUAS EXISTING	LUAS REVIEW DESAIN	SISA	LOKASI REVIEW DESAIN 2020
1	DIR. KURIK	15,000	5,000	10,000	Kurik 3 dan Kurik 4
2	DIR. SEMANGGA	5,700	5,000	700	Semangga 1, 2, 3 dan 4
3	DIR. TANAH MIRING	10,000	5,000	5,000	Tanah Miring SP 3, 4, 5, 6 dan 8
4	DIR. SERMAYAM EROM	5,000	5,000	-	Sermayam 1, 2 dan Erom
5	DIR. SALOR	6,543	-	6,543	
6	DIR. WAPEKO	5,300	3,000	2,300	
7	DIR. TANAH MIRING RAWA BURUNG	10,000	5,000	5,000	Lokasi Baru
	TOTAL	57,543	28,000	29,543	

Table 1-10 Scheme undergoing rehabilitation design in 2020

No.	Scheme	Subdistrict	Area (ha)
1	Review Design DIR Kurik 3 & 4	Kurik & Malind	5,000
2	Review Design DIR Semangga 1 - 4	Semangga	5,000
3	Review Design DIR Tanah Miring 3 - 8	Tanah Miring	5,000
4	Review Design DIR Sermayam & Erom	Tanah Miring	5,000
5	DED DIR Wapeko	Kurik	3,000
6	DED Tanah Miring Rawa Burung	Tanah Miring	5,000

Scope of Work required for the detailed engineering design (DED) for the Merauke District Irrigation Area carried out by the 2020 design consultants:

1. Conducting Pre-Consultation Meeting.
2. Preparation of Contract Quality Plan and its Implementation.
3. Coordinate with relevant regional agencies in relation to development programs in Merauke District and regional development planning at the location of activities.
4. Procurement and preparation of facilities needed in carrying out the work, including field offices and their equipment, equipment and personnel mobilization, permits, initial data, work plans and field reviews
5. Collecting primary data and secondary data available at the relevant agencies, including:
   - Inventory of Regional Spatial Plan Data (RTRW) at the location of the activity plan
   - Inventory of POLA and RENCANA Document
   - Inventory of Topographic Map Data with a scale of 1: 50,000 or greater, Aerial Photo Data and Satellite Imagery, Regional Geological Map Data, and existing Geotechnical Data from previous studies as well as activity studies in other sectors/agencies related to the area around the planned activity.
   - Inventory of District, Sub-District and Provincial Statistical Data
   - Inventory of hydrological, climatological, hydrometrical data (including flood recording data) and hydrogeology from rain stations, measuring instruments around the planned activity and agencies related to these data (e.g. BMKG);
   - Agro-socio-economic data inventory.
   - Inventory of General and Special Description of Irrigation Areas and the environment around the planned activity.
   - Inventory of data regarding construction materials around the planned activity area that may be used for construction.
   - Inventory data regarding the number, condition and location of existing Water, Hydraulic and Electrical Buildings.
   - Inventory data on Irrigation Conditions (if any) including types/irrigation systems, land use, and existing land cover.
   - Inventory the area and location of protentional area
   - Inventory of data regarding transportation as an illustration of project accessibility.
   - Inventory of Infrastructure Environment data that directly or indirectly affects the project.
   - Inventory map of the earth with a scale of 1:50,000, aerial photographs and satellite imagery to see the existing land use.
   - Results of surveys and investigations that have been carried out at the site or around the project site: topographic reference elevation, location, number, and elevation of BM stakes, detailed topographic and soil maps, registration of water level elevations.

6. Management Planning Stage
   a) Survey work, including:
      - Measurement of the main river topography according to PT 02
      - Checking the coordinates and elevation of the reference maps used
      - Hydrometric measurements in the main river
      - Agricultural Soil Survey, 1 sample for every 250 ha.
      - Socio-Economic Survey
      - Environmental Survey
      - Surface Geological and Geotechnical Survey

   b) Analysis
      - Topographical analysis including equating reference coordinates and elevation
      - Hydro-topographic Analysis
      - Hydrological and climatological data analysis includes analysis of river runoff and surface runoff, analysis of maximum-minimum and dependable discharge, analysis of

flood frequency, analysis of sediment and erosion, and calculation of the water balance (supply-demand) based on the regional master plan

- Identification of potential reservoir to meet water demand.
- Analysis of the suitability of agricultural land (existing conditions regarding colour, texture, structure, moisture level, soil slope, land use and soil surface form) equipped with a land suitability map with a scale of 1:50,000.
- Land use analysis is adjusted to the general regional spatial plan
- Preliminary analysis of main building site plans and irrigation canal alignments.
- Socio-Economic analysis especially related to land status.
- Analysis of geology and soil mechanics for soil classification, detailed geological formations, seismicity.
- Analysis of river infrastructure and transportation

c) Irrigation Layout map

1.8 Consultant tasks under the design stage

The objective of this Consulting Services is to assist the Directorate of Irrigation and Lowland (DILL), Directorate General of Water Resources (DGWR), Ministry of Public Works and Housing (MPWH) in development planning activities and management of irrigation areas in the lowland swamp areas of Merauke District. The services will be delivered in a thorough, integrated and environmentally sound way in order to realize sustainable national food resilience. The aim is to produce a comprehensive plan that takes account of socio-economic aspects, conservation and other environmental priorities, and administrative and management responsibilities. Integrated planning is the target that takes the interests of the various sectors and regional administrations into account. Sound environmental planning is planning that pays attention to the balance of the ecosystem and supports the environment. Sustainable development planning is not only intended for the benefit of the current generation but also considers benefits for future generations.

The purpose of the Consulting Services is:

1) In Phase I:
   a. The preparation of a Master Plan for the sustainable development of 750,000 ha of lowland (swamp) area (= gross project area) in Merauke District in Papua province.
   b. Conduct a feasibility study for 200,000 ha (within the overall 750,000 ha included in the Master Plan) for the development and sustainable management of Integrated Swamp Irrigation Area; with the target for detailed design for 50,000 Ha.
   c. Prepare a detailed engineering design for 25,000 ha (Phase-I) (within the 200,000 ha included in the feasibility study) for a Pilot Project area; this is to include technical designs, and TORs, among others for conducting EIA and LARAP for the targeted area.

2) In Phase -II
   Prepare a detailed engineering design for 25,000 ha (Phase-II) (within the 200,000 ha included in the feasibility study) for a targeted area; this is to include technical designs, and TORs, among others for conducting EIA and LARAP for the targeted area.

The Target Outputs:

1) Phase-I
   a. Master Plan for 750,000 ha of coastal lowland in Merauke.
   b. Feasibility Study for 200,000 ha of coastal lowland in Merauke District
   c. Detailed Engineering Design, EIA, LARAP for 25,000 ha of coastal lowland in Merauke District

2) Phase-II:
   Detailed Engineering Design, EIA, LARAP for 25,000 ha of coastal lowland in Merauke District. The Detailed Design and Feasibility Study are to be nested within the area covered by the Master Plan.

1.9 Preparation for design

It is important to notice that the success of the development of the schemes has been made in conjunction with the various bodies, and the design drawn up and approved. Any design adjustments and changes made later should also be in consultation with the arrangement with those bodies.

Indeed, some discussions have been made throughout the planning and design period. Firstly, with the ultimate client (BWS Papua, Pemda of Province as well as Pemda of Merauke District, and local people) in securing preliminary data for hydrological, agriculture and general planning purposes.

It is then followed by meetings with the BWS, and Pemda for relevant information and plans. There have also been meetings with the contractors and consultants to get recent data on site investigations, surveys, and construction.

1.10 Standards

The Indonesia standards from the DGWR KP Design Standards (2013) have been used wherever applicable. When necessary, the British Standards Code and Practice have also been used. For example, it has been used for reinforced concrete for water structures.

In general, calculations were made to a higher accuracy; but, to obtain the final design dimensions round off to suit the type of material and tolerance of the workmanship were involved.

Metric units are used in this report is MKS (meter–kilogram–second), but sometimes imperial units too.

1.11 Report structure

This report summarises the Stage 1 Detailed Engineering Design and its various components, and largely follows the format provided by the Ministry of Public Works and Housing. It describes the data availability, standards have been used, design requirements, and design layout plan, and the design of canals and related water infrastructures, as well as the specifications.

Chapter 1 of this report provides an introduction

Chapter 2 describes the land survey and mapping

Chapter 3 describe irrigation water canals and flows including canal layout, irrigation management and water distribution

Chapter 4 describes the canals and control structure design and its dimensions

Chapter 5 outlines the water flood protection management and its design

Chapter 6 outlines the technical specification

Chapter 7 provides the information on the bill of quantity of construction works

Chapter 8 provides the conclusion and recommendation

There are some appendices in this report:

Appendix A: Derivation of irrigation water requirements

Appendix B: Flood protection design

Appendix C: Canal design

Appendix D: Structure design

Appendix E: Pump station design

Appendix F: Layout Plan and Schematic Diagram

Appendix G: Design drawings

Appendix H: Bill of quantities

2 Land survey and mapping

2.1 General

This chapter summarises all the land survey to support the detailed engineering design of Phase 1; however, the data also can be used for the detailed design of phase II of this project. The land survey covers several activities: (i) topography with LiDAR survey, (ii) canal inventory, (iii) hydrometry, (iv) geotechnical survey, and (v) socio-economic data.

Mapping would include land unit description that describes (i) lowland irrigation potentials based on its hydro-topographical conditions; (ii) drainability and flooding; (iii) water supply possibility, and (iv) river salinity intrusion, based on hydrometry data.

In soil mapping (see soil survey report), every part of the study area is evaluated for its suitability of land for various types of use along with development constraints. (i) Rice crops consist of: rain fed, tidal irrigation and pump irrigation, (ii) Seasonal crops: secondary crops, maize, beans, vegetables, etc. (iii) Annual crops: coconut, oil palm, etc. This soil mapping was carried out during the soil investigation; and the results has been used for development decision making.

2.2 Previous survey works and mapping

Previous topography surveys and mapping is partial coverage; each block of schemes has its own geodetic datum. It is very difficult to combine in one system geodetic system as it distributed over the large area, and the presence of the benchmarks that had been used are now hard to find. Not every scheme has the same quality of mapping and layout.

There also some data on the soil suitability of some schemes where the improvement design has been carried out lately. Hydrometric surveys were also conducted during that time, as well as the geotechnical surveys.

The following table provides the availability of topographic, soil suitability, hydrometry, and geotechnical data for every scheme. It should be noted that the quality of the data are varies from scheme to scheme.

Table 2-1 Availability of topographic, soil suitability, hydrometry, and geotechnical data

No.	Scheme	Topography	Land Suitability	Hydrometry	Geotech
1	Kurik 1,2,4,5, Kumbe Kampung	ü	ü	ü	ü
2	Salor 1,2,3, Salor Kampung	ü	ü	ü	ü
3	Tanah Miring 2,4,7,9	ü	ü	ü	ü
4	Kuprik Sidomulyo	ü	ü	ü	ü
5	Sermayam New	ü	ü	ü	ü

For the planning and design purpose, layout plan and canal conditions are required. Almost every scheme system layout is quite complete; it gives the data on the canal alignment, and length. However, there is no information available from previous surveys about the canal dimension and the existing conditions. The existing system layouts are presented in the Sections 1.3, 1.4 and 1.5.

On the aspect of water management, on how to allocate water in the scheme, and the control of water flows, there is no information. In the field farmers obtain water from the drainage canals, or long storages or any source of water based on their own decisions.

2.3 Design process and requirements

2.3.1 Design process

In fact, the planning is aimed to set the priority of the development and arrange the stage of the development; while the DED is aimed to present engineering design documents that can be used for the construction activities. The land use planning, irrigation planning and the detailed design should be based on the distinct aerial photography and accurate topographic surveys. Photography and survey results are combined in orthophoto mapping. From that orthophoto the planner /designer can see the land formation and contoured overlay in accurate plan (coordinates) and clear rectified photography where buildings, channels and field boundaries can be clearly seen. The information is very useful for the planner /designer to plan the alignment of the canal system at its correct position and where the existing capacity is sufficient, related to the existing width.

The conduct of the survey, investigation and design (SID) in the preliminary study and the detailed technical planning study, basically follow the same rules. The difference lies in the intensity of the survey and the level of density of observations as well as the detail of the design. For example the LiDAR photomapping was not available for the 1:25,000 layouts which were superimposed with the LiDAR DEM on high resolution satellite imagery.

(1) Collection and review of available data.

- Topographic maps, distribution of soil types and land use.
- Aerial photos and satellite photos.
- Climate and rainfall data.
- Tidal forecast data.
- Statistical data and development plans.
- General spatial plan and river basin master plan. For swamp irrigation land that has been cleared (existing schemes):
- Inventory data of swamp irrigation areas.
- The results of previous surveys such as:
- base elevation (reference level) topography.
- location, number and elevation of benchmarks (BM).
- detailed topographic and soil type maps.
- water level observation data.
- current land use and socio-agro-economic data.
- Previous assessments of irrigation infrastructure.

(2) Preparation and preparation of survey plans.

Preparation in the form of preparation of survey plans and detailed investigations including field survey plans, staff/personnel needs, schedule of activities for logistics needs, making of temporary land unit maps showing topography, soil, hydrology, as well as paths and observation points.

In addition, it is necessary to prepare:

- the type of data to be collected and the form it contains;
- a questionnaire or list of questions for farmers and local government staff.

The implementation plan for the detailed technical planning survey should be made in greater detail than the preliminary study.

(3) Field surveys

- The minimum field survey includes:
- Topographical mapping,
- Hydrological and hydrometric surveys (rainy season and dry season).

- Agricultural land survey.
- Socio-agro-economic survey.
- Inventory of land use.
- Soil mechanics research (only for detailed design).
- Inventory of existing irrigation and related infrastructure (specifically for irrigation of swamps that have been cleared).
- Environmental survey (AMDAL).

For the purposes of detailed technical planning, a hydrometric survey ideally should be carried out continuously for a long period of time (especially for water level observations) over a full annual cycle. However, in this project a series of delays reduced the survey to just 2 months.

From the field data after analysis, survey and thematic maps have been prepared: for topography, hydro-topography, soil, land use and crop suitability planning.

From the hydrological data, land elevation and HECRAS 1 and 2 D hydrodynamic modelling, the swamp land flooded by river floods can be determined, the land that can be drained and protected by flood banks, and the land that has the potential for irrigation.

(4) Land unit map and land suitability

The Land Unit Map describes the following aspects:

- Irrigation potential
- Soil suitability for a range of crops.
- Flooding and drainability.
- Existence of peat soil.
- Presence of potential acid sulphate soils.
- Saltwater intrusion.

Each land unit is evaluated for its suitability of land for various types of use along with development constraints.

- Rice crops consist of: rain fed, tidal irrigation and pump irrigation.
- Seasonal crops: secondary crops, maize, beans, vegetables, etc.
- Annual crops: coconut, citrus, other fruits and nuts etc.
- Residential land including the suitability for *pekarangan* and *kebun* areas for piped irrigation.

On land that has been cleared, land suitability can be adjusted to the existing field conditions and wishes/consultation with farmers. Land that has been cultivated for some time will have changed suitability if enhanced by ploughed in organic material. Temporary land use plans have been prepared with various cropping options. Irrigation possibilities and drainability are very dependent on the location as well as the type of channel and water control structures made that usually require adjustment at a later stage when water management improvements need to be made.

(5) Public consultation

For swamps that have been cleared, survey results such as: evaluation of land suitability and provisional land use plans should be explained and discussed with farmers and related agencies (Bappeda, PUPR Service, Agriculture Service, Plantation Service, etc.).

Land use decisions should be based on:

- The wishes and aspirations of farmers.
- The available natural resources infrastructure in the area concerned.
- Land suitability.
- The current state of marketing and possible future developments.

For land that has been abandoned by farmers, during the preliminary study. it is necessary to decide whether the land needs to be studied in more detail or not.

(6) Development options

For detailed technical planning: the concept of a system plan (system planning) describing:

- Development plan, for land that has been cleared with an agreed land use.
- Location, area and layout of settlements, as well as relocation of farmers who are located on unsuitable land (on land that has been identified by authorities for other use such as urban development).
- Provision of a green belt (greenbelt).
- Goals and boundaries for water management
- Construction of primary, secondary and collector channels.
- Construction location and type/type of water control structures.
- Construction of transportation networks (roads, culverts, bridges, piers).
- Flood protection, drinking water, sanitation, health, education, counselling
- Arrangement of water management and operation of water control structures.
- Whether the irrigation network could also support rural water supply in areas of either poor service or poor quality.
- The need for maintaining the natural resource network, including the responsibility of farmers and the government.

(7) Detailed design

The development plan is presented in the form of a map on a scale of 1: 25,000, describing the current and proposed infrastructure conditions, as well as the advantages and disadvantages of each proposed option. Consultations/discussions should be coordinated by Bappeda (Province/District) While discussions with farmers are organized by the Camat and Village Heads through focussed group discussions (FGD's)2. As a result of discussion/consultation, the scheme development plans are adjusted according to the result of mutual agreements.

On detailed engineering design, after the draft being approved by the relevant agencies, a detailed engineering design is drawn up together with BOQ and cost calculations, procurement documents, as well as operating and maintenance

(8) Participations

Relevant agencies that are expected to participate in swamp development planning and design are:

- Ministry of PUPR: - Directorate General of water resources – Central and regional,
- Ministry of Agriculture: - Directorate General of Land and Water Management, Directorate General of Food Crops Agriculture and Directorate General of Plantation (Central and regional).
- Ministry of Home Affairs: - Ditjen Bangda and Pemda (Province and Regional Government)
- In lowland irrigation land that has been cleared, the active participation of farmers through existing farmer organizations such as farmer groups and P3A

2.3.2 Data requirements

To arrange a good lowland irrigation plan and design, some data are required:

1. Topographic maps: Topographic maps can be obtained from LIDAR surveys with the scale 1: 50,000 and 1: 5,000.

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[2] Whilst FGDs for multiple communities were arranged only some 6 were carried out due to Covid19 restrictions and lack of approved budget.

2. Aerial photo: Aerial photos can be obtained from various government agencies such as from the Ministry of Forestry and BIG (*Badan Informasi Geospasial*), and also from LiDAR activity.
3. Satellite photos and radar photos can be obtained from BIG and LAPAN. The most suitable satellite photos were produced by Landsat TM (30 m resolution) and SPOT B&W (10 m resolution), while radar photos were produced by Radarsat, ERS-1 and ERS-2.
4. Climate and rainfall data. Climatic data such as temperature, humidity, wind direction and speed, duration of irradiation, and rainfall can be obtained from the airport closest to the Meteorology and Geophysics Agency (BMKG) – Jakarta for determining crop water demands.
5. Tidal data and salinity intrusion, from the direct field surveys at least for 15 days. From that, tidal parameters and salinity penetration up the rivers can be estimated.
6. Statistical data and development plans. Statistical data on population and regional economic activities to be developed can be obtained at the local government office or the village head office. Likewise, the development plan, it may have been made separately or integrated with RUTR or river basin development plan

The major surveys and mapping that have been carried out:

1. LiDAR survey on about 200,000 ha of the feasibility areas and followed with the orthophoto mapping with the scale of 1: 5000. The results have been used for system planning and design, combined with the result of (2) canals topographic survey;
2. Canals topographic survey of 240 km; to map the existing canal cross sectional and long sectional shapes. The major suppletion, the primaries and related secondaries have mainly been surveyed, especially where water can be observed in the canal that prevents the LiDAR equipment penetrating it to bed levels.
3. Hydrometric survey: mainly focussed on the flow characteristic of the main river, as it become a major boundary condition of the plan and design works;
4. Geotechnical survey: based on the previous surveys and by the local consultants during the rehabilitation design of several schemes. For new schemes a new survey was carried out. The focus of the survey is to confirm the previous data and to obtain geotechnical data in the DED area that are not covered by the previous surveys that allows foundation design to proceed.

2.4 LiDAR mapping and topography survey

2.4.1 Mapping with LiDAR technology

LiDAR (light detection and ranging) is a new technology that is quite phenomenal in the geospatial field. This technology has become increasingly needed and has played a role since the enactment of the Geospatial Law in 2011. This law mandates the provision of information on the appearance of the earth at a scale of 1:1000 by the Geospatial Information Agency. This LiDAR technology can answer the needs of providing such data.

Currently, mapping using a laser beam carried on an aircraft is the most efficient mapping system for extensive areas compared to direct surveys or photogrammetry and remote sensing. This technology is capable of acquiring data at up to 200 Khz or 200,000 dots per second. In addition, LiDAR can generate altitude data with a density of 25 points/m2,

Mapping systems using LiDAR are not only faster and more accurate, but they are also cheaper. The cost of LiDAR technology using an airplane costs 100 thousand rupiah per hectare, with a minimum area of 10,000 hectares. Although it is efficient, the utilization of LiDAR in Indonesia is still very minimal because each recording requires a fairly expensive cost to rent an aircraft.

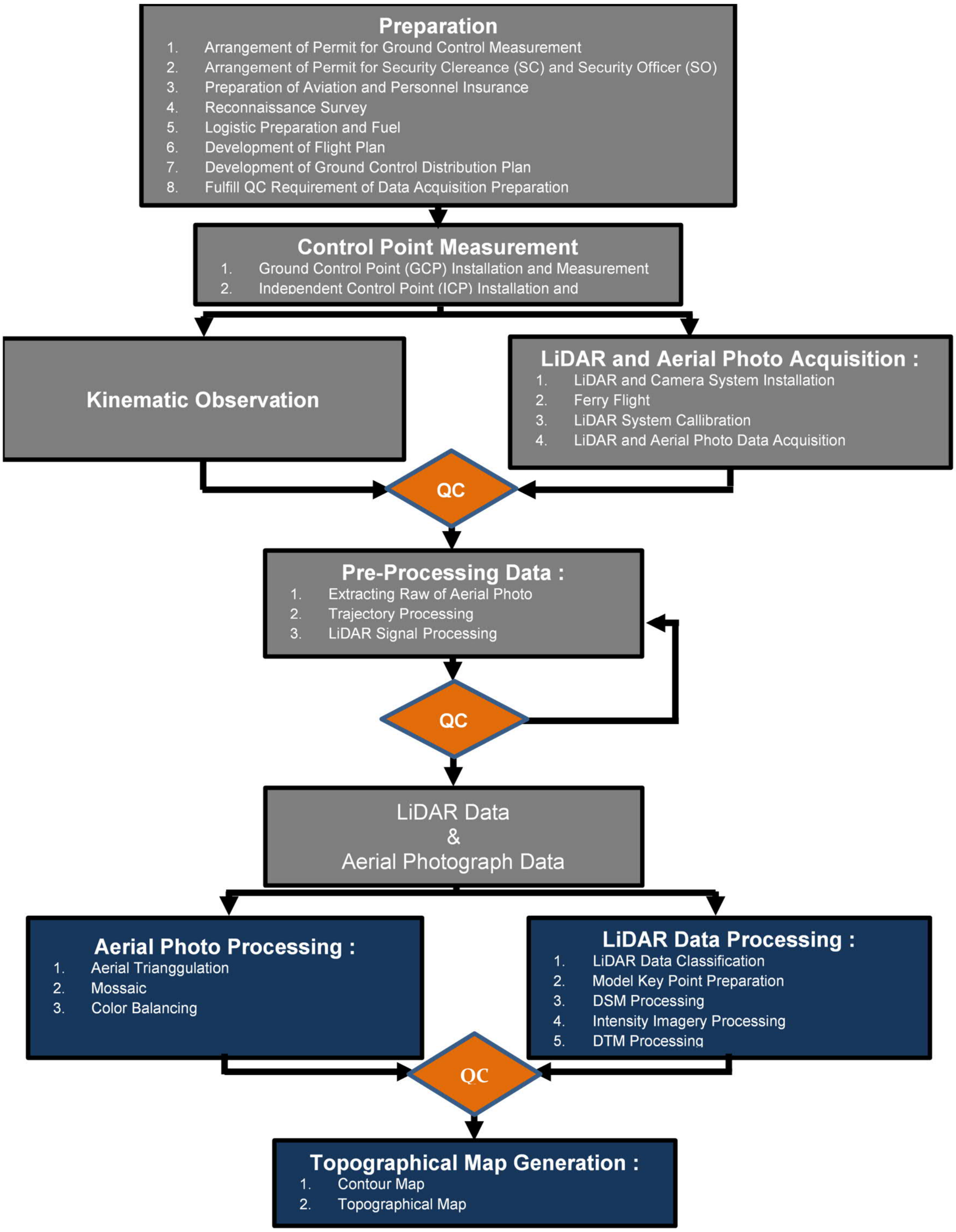
LiDAR is a technology in the field of survey mapping that relies on sensors & radar. Where now it is widely used in various fields, one of which is for mapping activities. Mapping using LiDAR is often used for topographic mapping, Mining, Civil, Planning and inspection.

Please note that LiDAR stands for light detection and range. The way the LiDAR sensor works is by reflecting the laser off the object. The point is, to measure the distance based on how long it takes the light to return to the sensor.

The working principle of the LIDAR system in general is that the sensor emits a laser beam to a target on the earth's surface, then the laser beam is reflected to the sensor. The working combination of the laser sensor components can provide data to determine the distance from the sensor to the object.

The workflow of LiDAR survey can be seen at **Figure 2-1.**

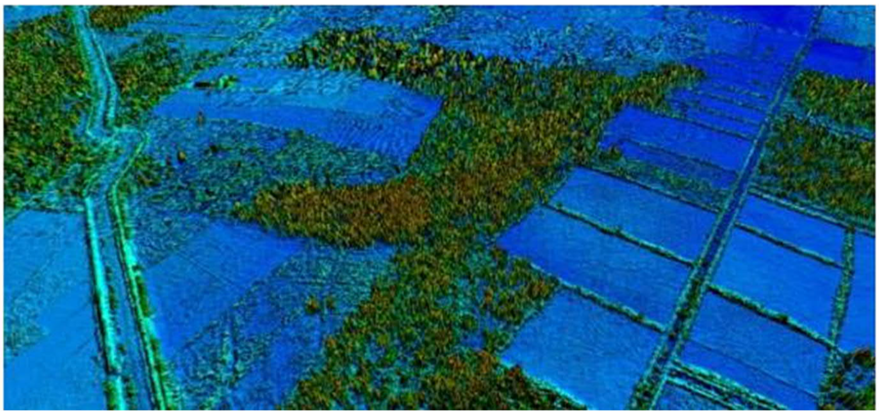
Figure 2-1 The workflow of LiDAR survey



Products resulting from the LiDAR mapping:

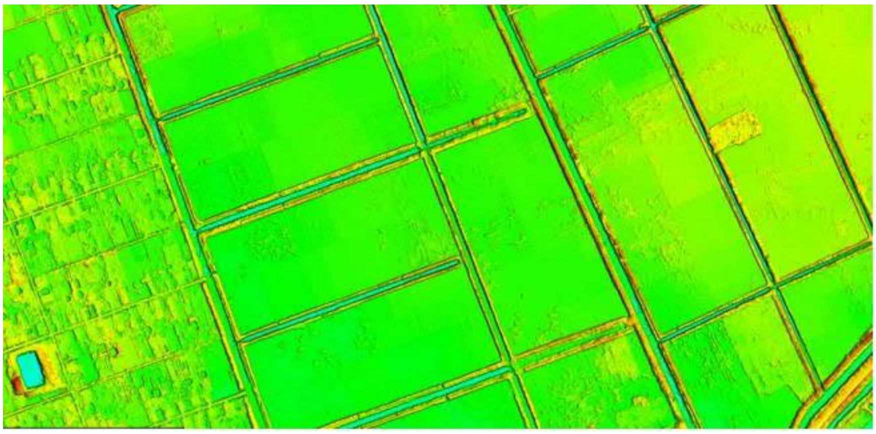
1. **DSM (Digital Surfaces Model)**

Figure 2-2 DSM (Digital Surfaces Model)



2. **DTM (Digital Terrain Model)**

Figure 2-3 DTM (Digital Terrain Model)

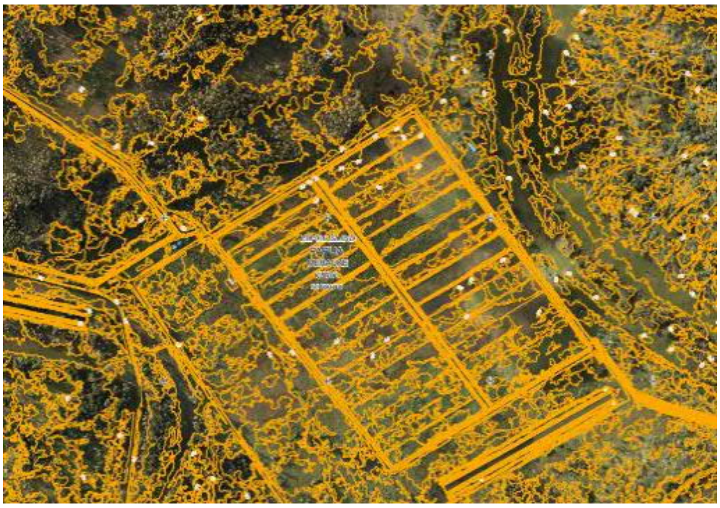


3. **Aerial photography**

Figure 2-4 Aerial Photography

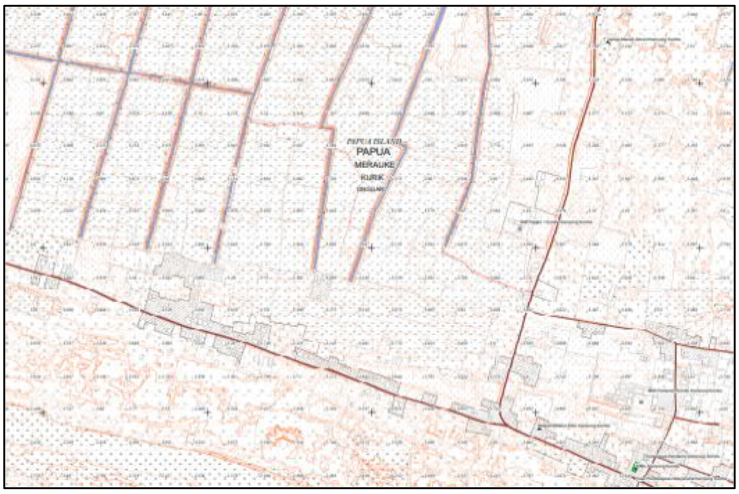
4. Contoured orthophoto

Figure 2-5 Orthophoto with contour lines



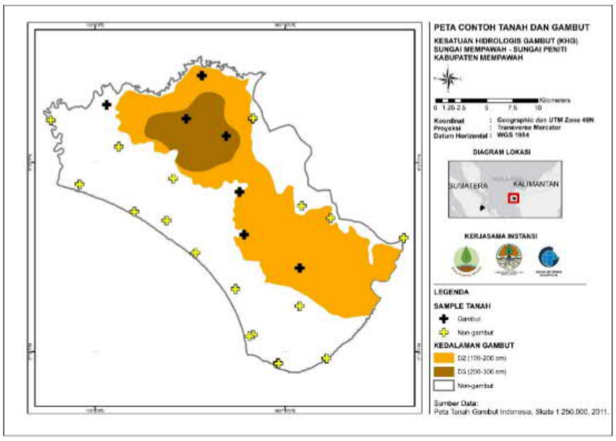
5. Contour map

Figure 2-6 Contour Map



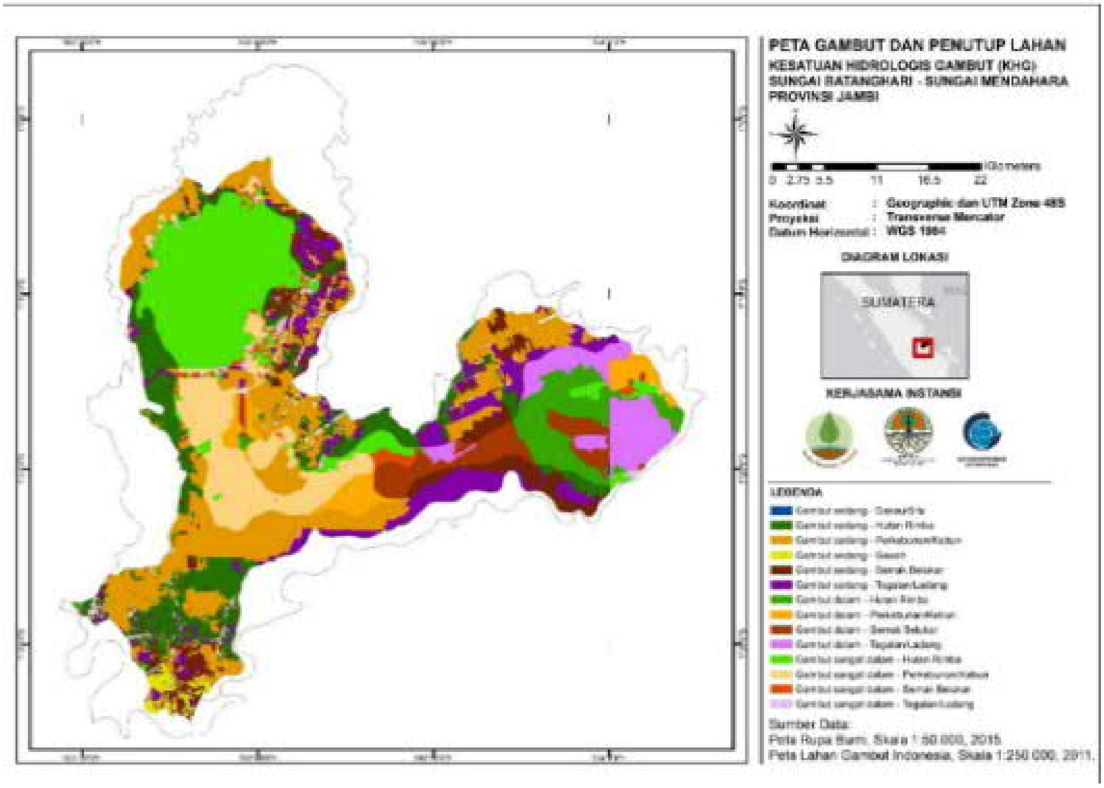
6. Soil map

Figure 2-7 Soil Map



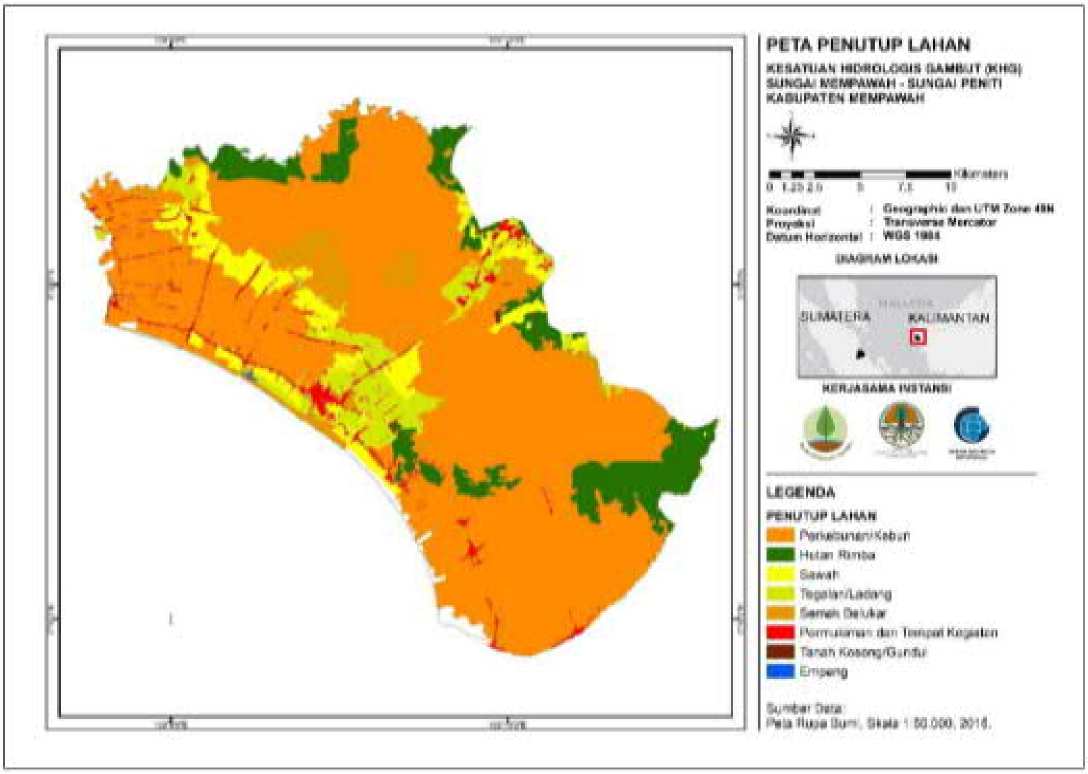
7. Hydrological unit map

Figure 2-8 Hydrological unit map



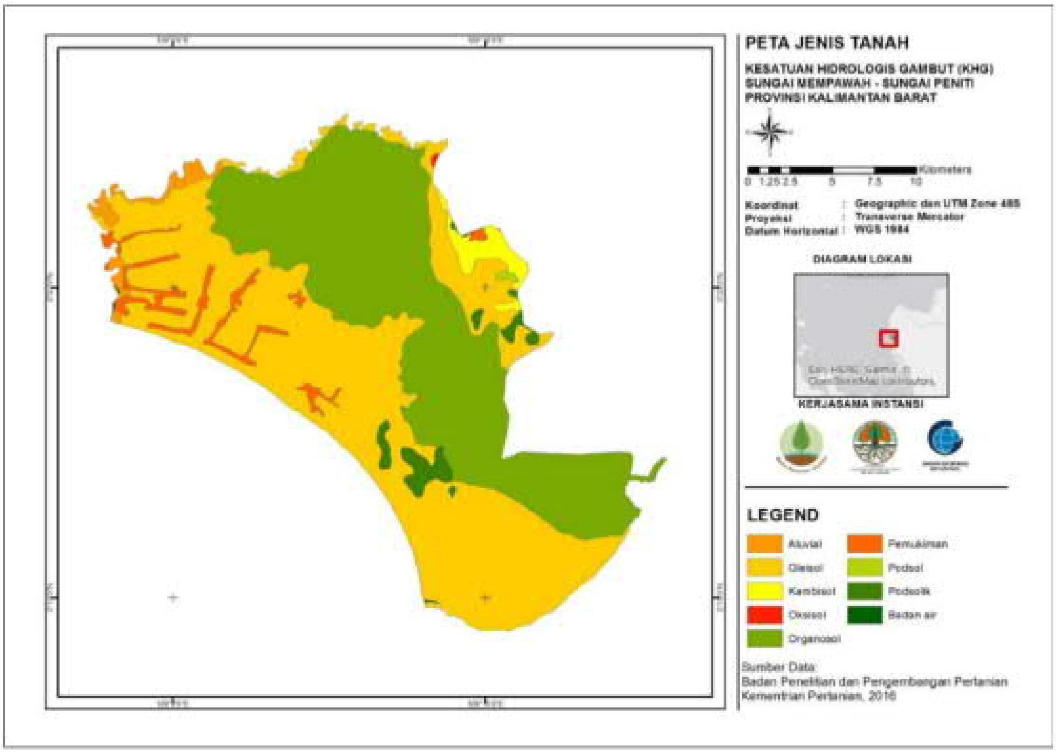
8. Land cover map

Figure 2-9 Land cover map



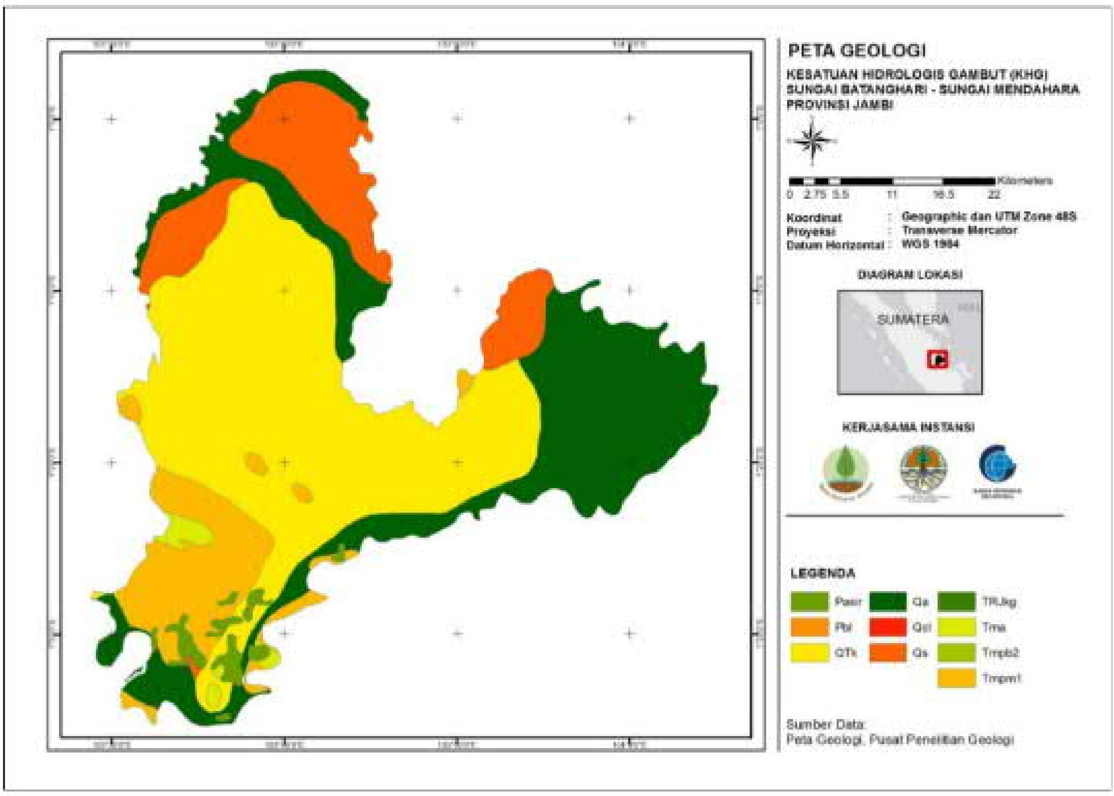
9. Soil type map

Figure 2-10 Soil type map



10. Geological map

Figure 2-11 Geological map

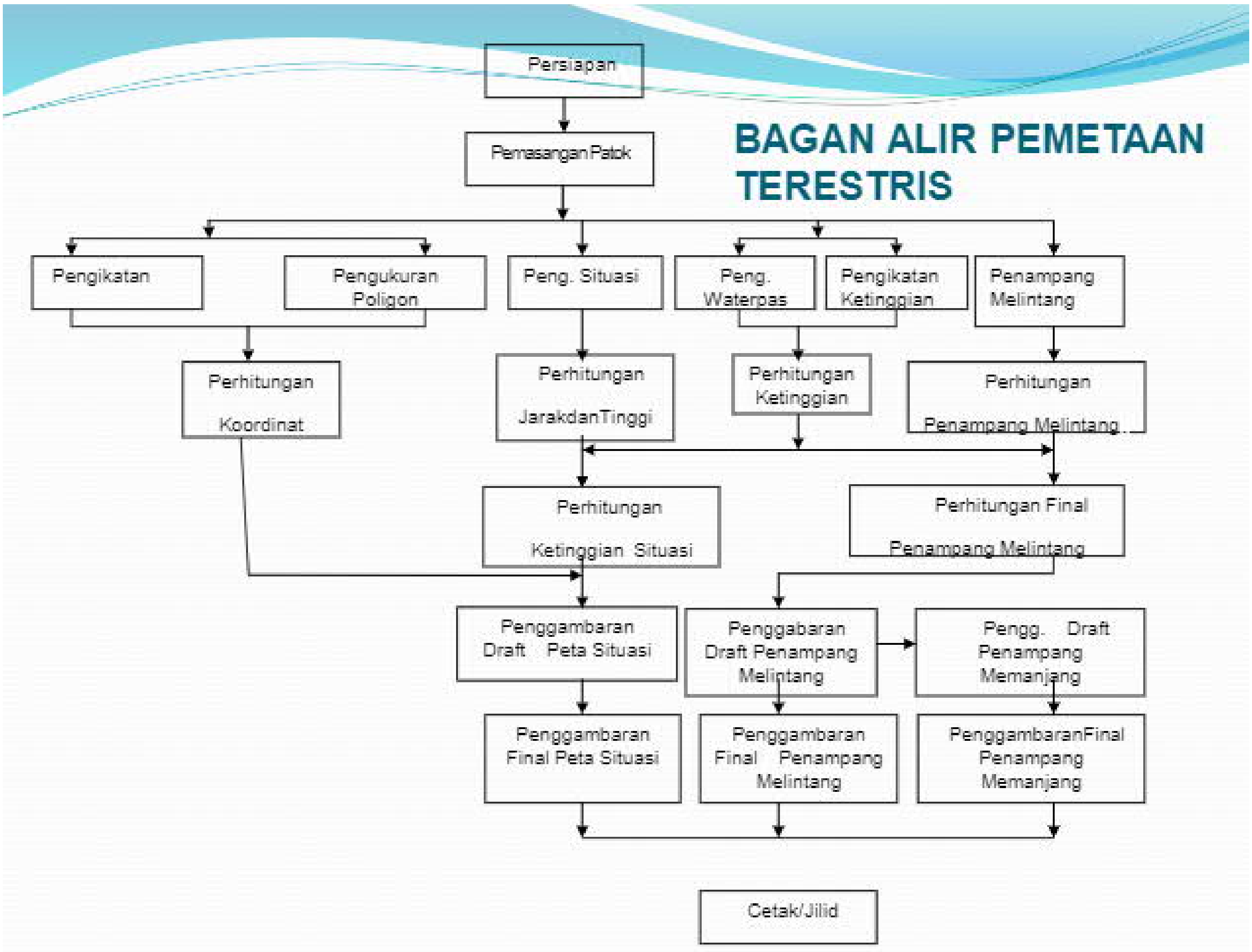


2.4.2 Topography survey

Topography (derived from the words "topos" which means place and "grapho" which means to write) is the study of the shape of the earth's surface and other celestial bodies, such as planets, satellites (natural, such as the moon), and asteroids. It also includes its depiction on the map. There are two techniques that can assist this topographic study, namely direct surveys and remote sensing. This time, we will discuss direct surveys or better known as topographic surveys.

Topographic survey is a method to determine the position of the signs (features) man-made and natural on the ground surface. Topographic surveys are also used to determine the terrain configuration. The purpose of topographic surveys is to collect the data needed for topographic map drawings. The map image from the combined data will form a topographic map. A topography shows the character of vegetation by using the same signs as the horizontal distance between several features and their respective elevations above a certain datum. The topographic mapping process itself is a mapping process where measurements are made directly on the earth's surface using terrestrial survey equipment. Mapping techniques have developed in accordance with the development of science and technology. With the development of electronic soil measuring equipment, the measurement process becomes faster with a high level of accuracy, and with the support of GIS technology, the steps and the calculation process become easier and faster and the drawing can be done automatically.

Figure 2-12 Terrestrial mapping flowchart



1. Installation of benchmarks (BMs)

As a binding point in topographical measurements, it is necessary to make a benchmark (BM) assisted by a control point (CP) which is installed regularly and represents the area evenly. Both types of binding points have the same function, namely, to store coordinate data, both coordinates (X, Y) and elevation (Z).

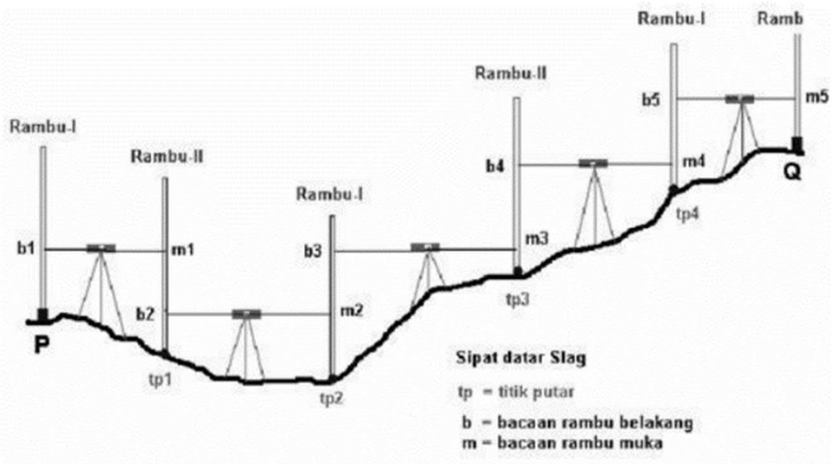
2. Polygon Measurement

In order to implement the basic framework of the map, in this case the horizontal base frame/horizontal position (X, Y) the polygon method is used. In measuring polygons there are two important elements that need to be considered, namely distance and angle.

3. Measurement of Water pass

The vertical base frame is obtained by measuring the plane of the polygon path points. The measurement path is closed (loop), the measurement starts and ends at the same point. Measurement of height difference is done by double stand and back and forth. The entire height of the traversed net (measurement frame points) has been tied to the BM. Determination of the vertical position of the basic frame points is done by measuring the difference in height between two points on the reference plane.

Figure 2-13 Measurement of water pass



4. Situation Details Measurement

The detailed measurement of the situation is carried out to obtain and determine the topography of the area to be mapped.

Figure 2-14 Situation Details Measurement (1)

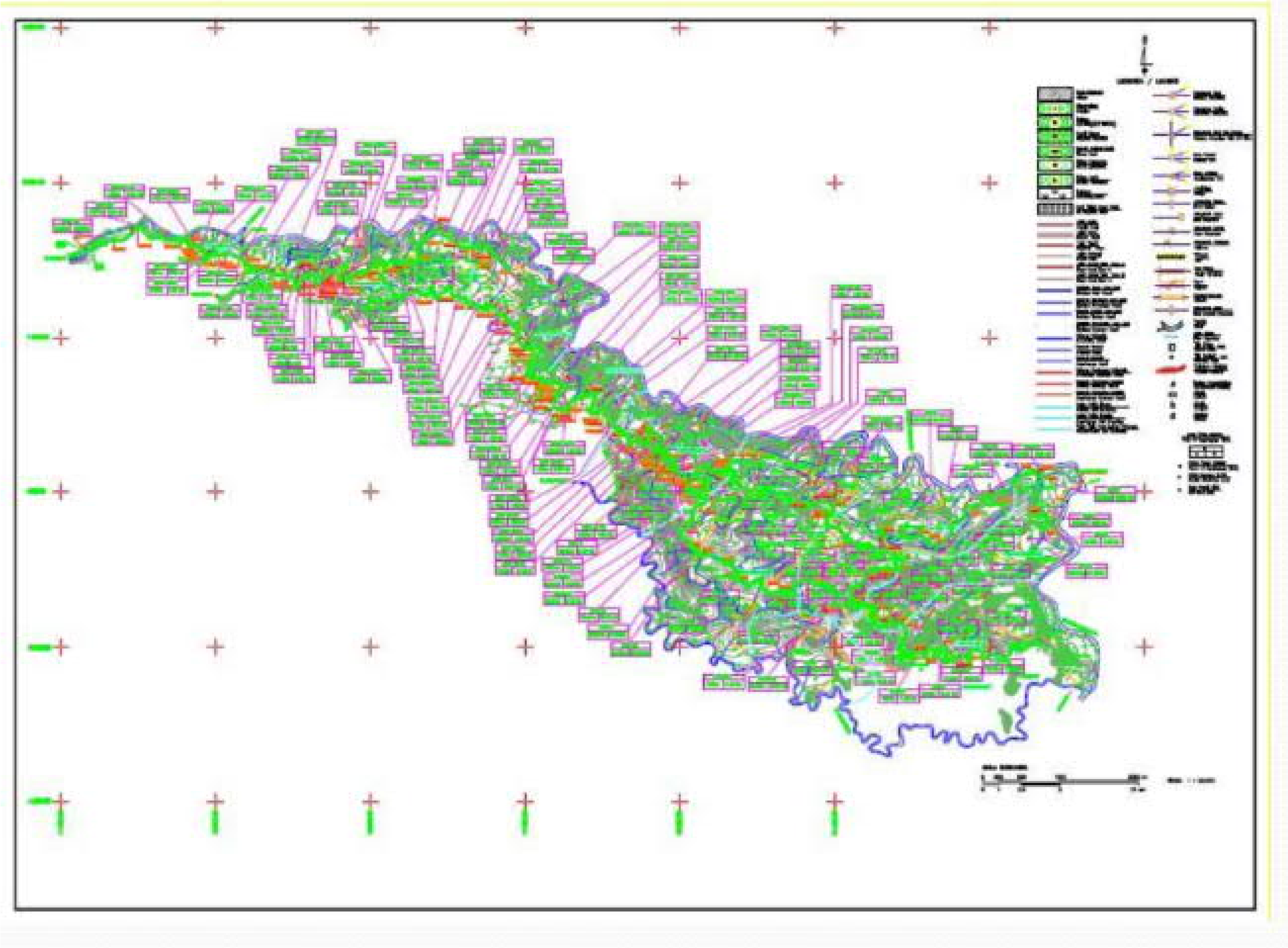


Figure 2-15 Situation Details Measurement (2)

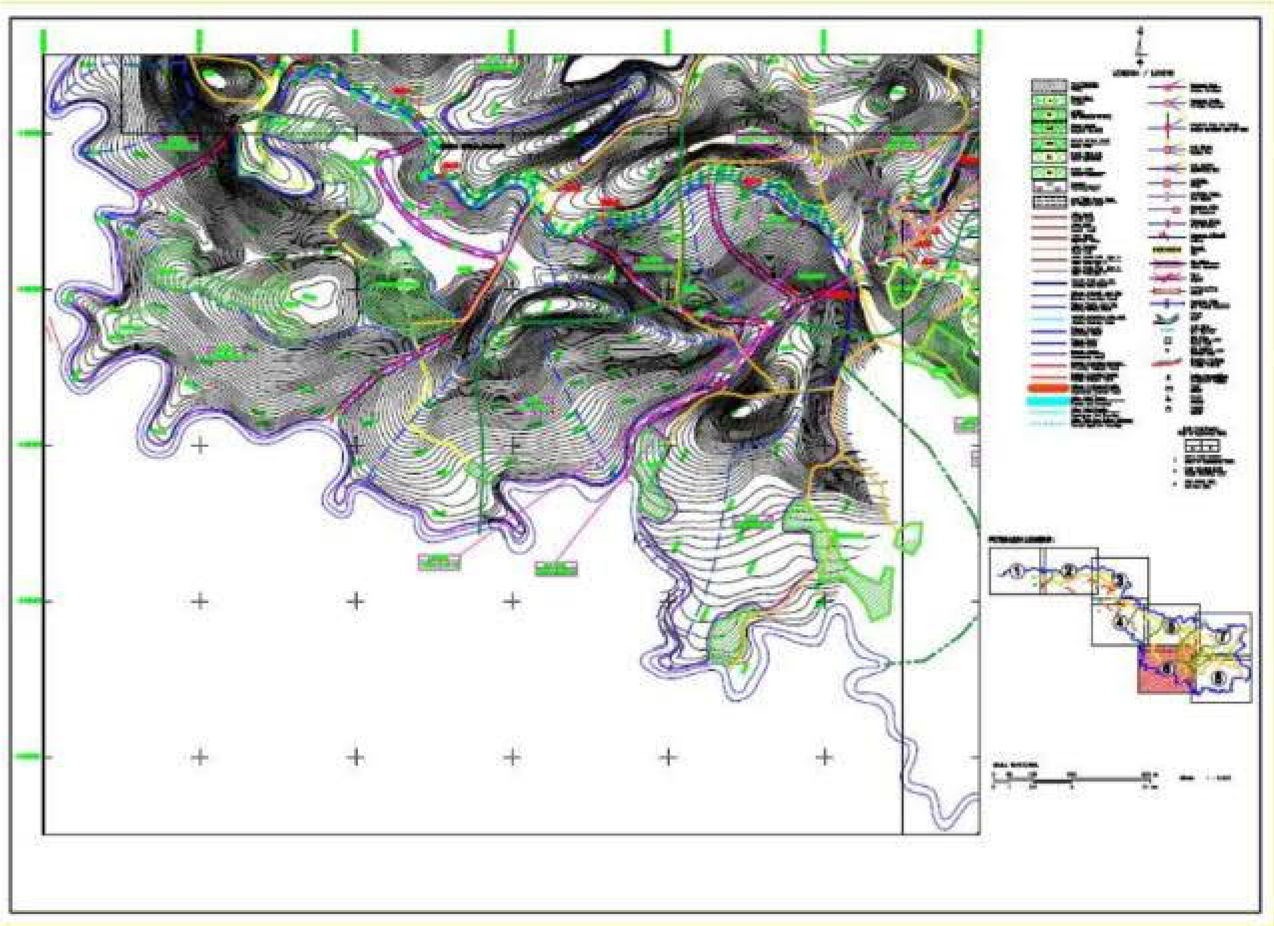
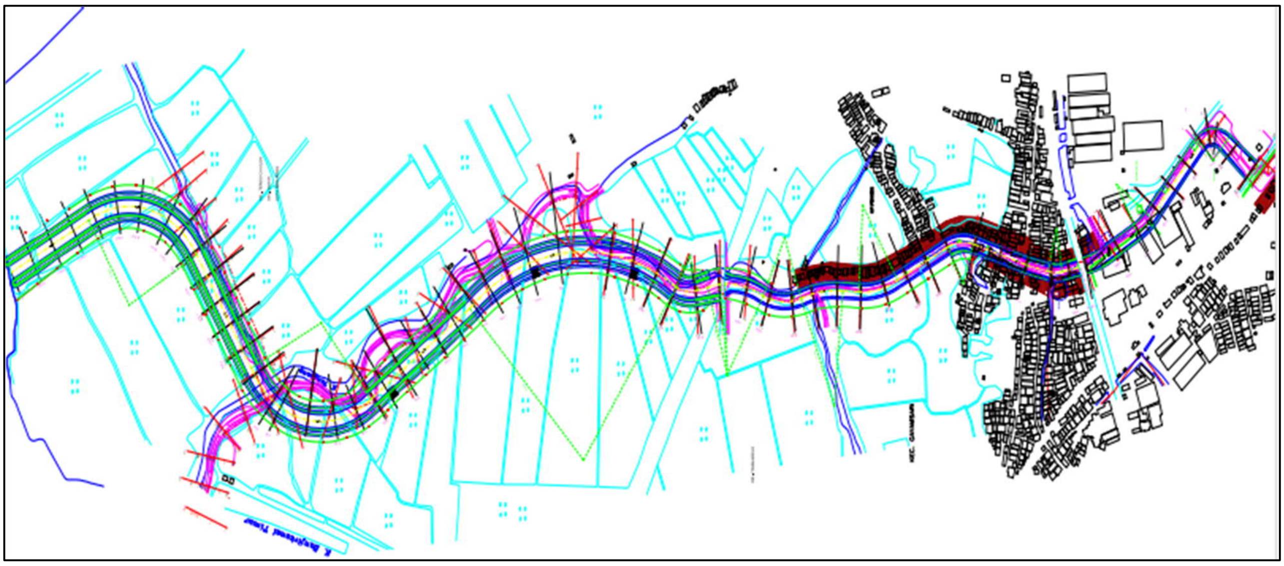


Figure 2-16 Situation Details Measurement (3)



5. Cross-sectional Measurement

The cross section of the river is intended to determine the condition of the ground surface in a position perpendicular to the river axis. This cross section is measured using the Theodolite Wild-TO. For flat areas, a water pass is used.

Figure 2-17 Cross section measurement

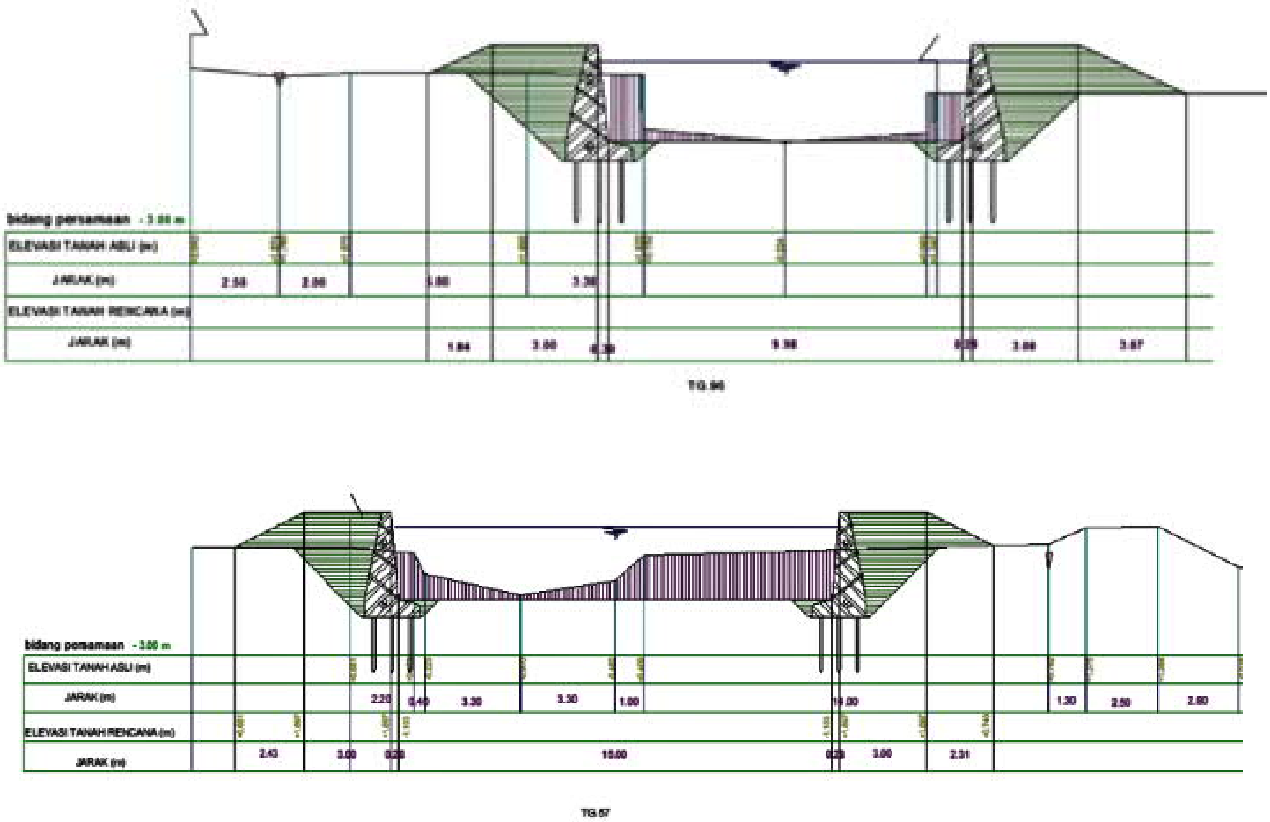
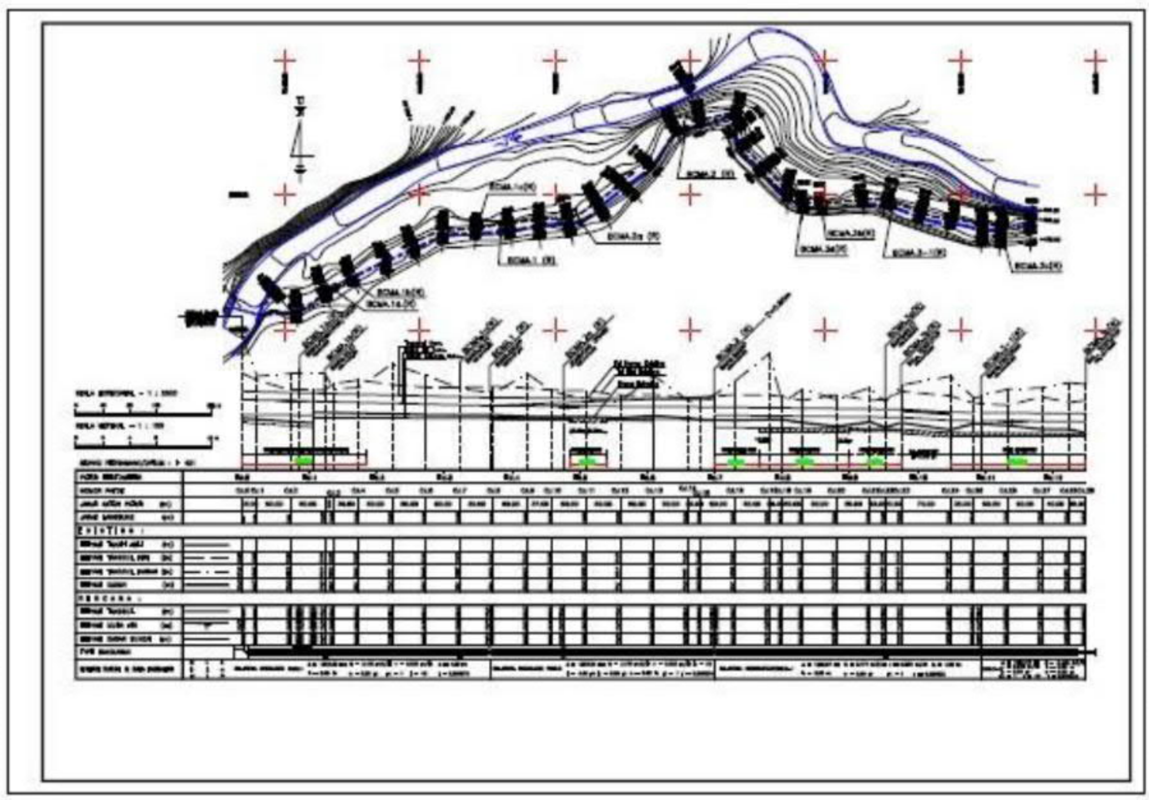


Figure 2-18 Long section measurement



2.5 Hydrometric surveys

2.5.1 Scope of work

The scope of work of this hydrometric survey includes:

1. Primary Data Collection
   - River Cross Section Measurement
   - Observation of water level
   - Flow velocity measurement
   - Measurement of water quality and Turbidity (Turbidity)
2. Data processing and analysis
3. Reporting

The output of this Hydrometric Survey is the result of Hydrometric Analysis at several locations along the Kumbe and Maro rivers.

Table 2-2 Location of the hydrometric survey

Point	Latitude	Longitude	X	Y	Location
WL.01	-8.356653	140.239177	416230.030	9 076.192.427	Pelabuhan Kumbe
WL.02	-8.276938	140.395294	433406.441	9085.035.426	Desa Salor
WL.03	-8.108206	140.462411	440 773,015	9 103.700.586	Desa Baad
WL.04	-8.479	140.38	431.757.342	9062 692.890	Pelabuhan Merauke
Wl.05	-8.319683	140.647047	461 135.530	9080.343.101	Desa Sermayam
WL 06	-8.149826	140.802486	478242.066	9099196.623	Desa Jagebob (PDAM Mimibaru)
CSK1	-8.292602	140.326500	425 833.036	9083.291.397	Kurik Harapan
CSK 2	-8.197036	140.430786	437.302.581	9.093.874.993	WAPEKO
CSW 1	-8.407287	140.487172	443 543.496	9 070.638.505	Mandira
CSM2	-8.257476	140,772281	474.921,496	9.087230.497	ERrom

Description:
WL = Water Level Observation Point
CS = Cross Section Measurement Point. Flow velocity, water quality. sediment transport and bedload.

Figure 2-19 Location of the hydrometric survey

2.5.2 River discharge analysis

Water discharge can be calculated from the following formula:

$$Q = V \times A$$

Where Q is the discharge (m3/sec), V is the current velocity (m/sec), and A is the cross-sectional area where the current acts (m2). Current data is obtained from the current measurement results while the cross-sectional area is obtained from the bathymetric profile measurements at the current measurement site. The direction of river flow will be the same as the direction of the current. In the case of a river, if the direction is downstream, then the discharge that occurs is river discharge, while if the direction is upstream, then the discharge that occurs is the discharge of sea water entering the river.

The discharge calculation is carried out by calculating the cross-sectional area of each slice multiplied by the average current in each slice of the 3 measured current depths, and the total discharge at each observation point is the result of multiplying the average current velocity with the cross-sectional area of the river. Based on the depth measurements made, the cross-sectional area at points CSK1 and CSK2 on the Kumbe River and CSM1 and CSM2 on the Maro River is as follows.

Table 2-3 Cross-sectional area of the river at the observation point

No	River	Observation Points	Cross Area	Observation Time
1	Kumbe River	CSK1	786 m^2	28 December 2021 13:00
2		CSK2	367 m^2	28 December 2021 12:00
3	Maro River	CSM1	2062 m^2	30 December 2021 17:00
4		CSM2	224 m^2	31 December 2021 10:00

Later, based on the time of data collection for the cross-sectional area of the river, a function was built to determine the cross-sectional area of the river to variations in the increase and decrease in river water level so that different cross-sectional area values were obtained and were accurate enough to calculate the river discharge value.

Kumbe River Water Discharge

There is an upstream flow of water at Point CSK1 which occurs once every 12 hours for 6 hours. Judging from the total discharge that flows during the measurement, the discharge is 333.38 m3/second the water flows downstream.

Maro River Water Discharge

There is an upstream flow of water at Point CSM2 which occurs once every 24 hours for 6 hours. The discharge that occurs when it flows upstream and downstream is relatively the same. If it is calculated at 25 hours on December 31, 2020, the downstream discharge is 863.15 m3/second and the upstream discharge is 804.72 m3/second so that at that time the difference in discharge is 58.43 m3/second. heading downstream. When viewed from the total discharge during the measurement, it is obtained at least 393,113 m3/second of water flow that leads downstream.

2.5.3 Water level data analysis

Kumbe River Water Level

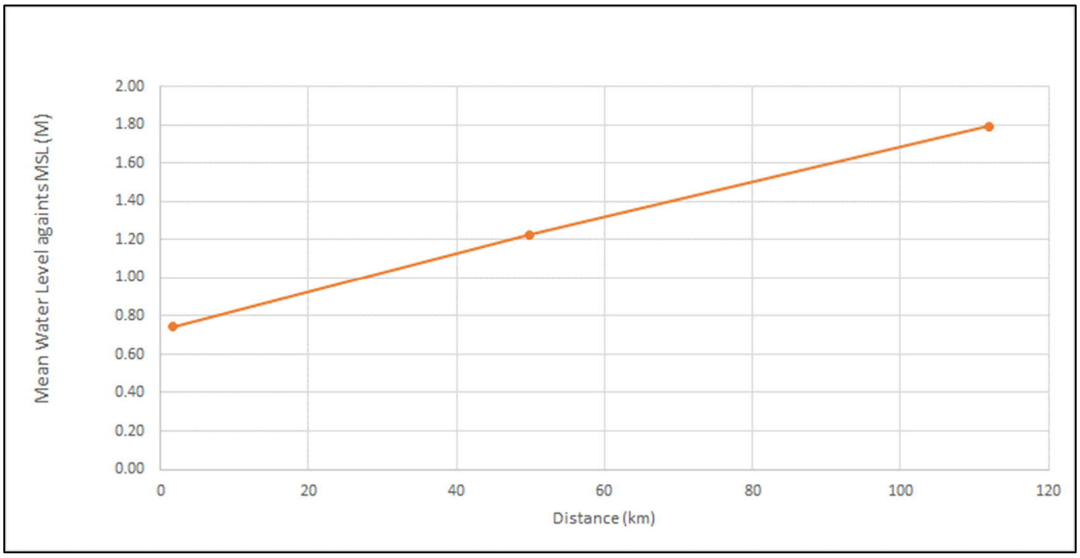
Tidal observations in the Kumbe River were carried out at three points, namely WL01, WL02 and WL03 with the distribution as shown in **Figure 2-19**. If the distance between observation points on the Kumbe River was calculated, the following results were obtained:

a) Kumbe River Estuary - WL01 = 1,622 meters
b) WL01 - WL02 = 48,271 meters
c) WL02 - WL03 = 62,010 meters

Table 2-4 Water level WL01, WL02 and WL03 to MSL (Mean Sea Level)

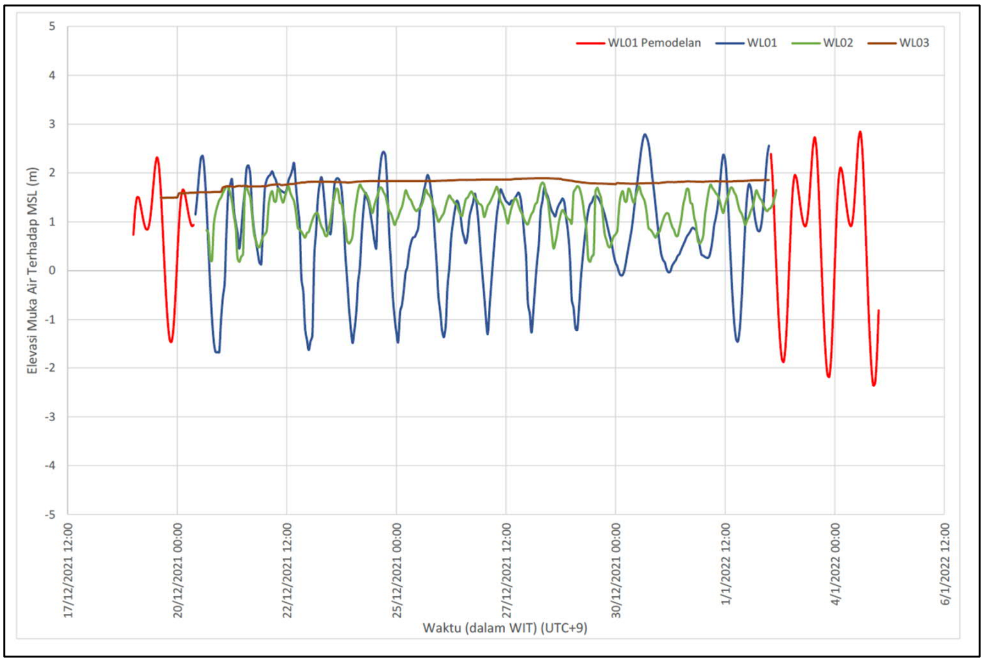
Titik Pengamatan Tinggi Muka Air	KOORDINAT BM				Data Tinggi				
	LAT	LONG	X	Y	Tinggi BM Terhadap MSL	Beda Tinggi BM dan Palem Pasut	Tinggi Palem	Nilai Duduk Tengah Terhadap 0 Palem	Nilai Duduk Tengah Sungai Terhadap MSL
WL01	-8.36	140.24	416230.03	9076192.43	3.417	-0.095	6	3.234	0.745
WL02	-8.28	140.4	433386.69	9085136.63	4.499	1.423	3	1.152	1.228
WL03	-8.11	140.46	440764.69	9103688.42	6.456	3.187	3	1.525	1.793

Figure 2-20 Mean Water level of the observation points WL01, WL02 and WL03



The graph of tidal observations at WL01, WL02 and WL03 is shown in the figure below.

Figure 2-21 Water level observations at WL01, WL02 and WL03.



The picture above shows that the downstream tide (WL01) has a tidal height of about 4-5 meters, while in the middle part (WL02) with about 48 km from WL01 it is still influenced by the tide with a tide of about 1.5 meters. In the upstream part (WL03) with about 110 km from WL01, the graph of sea level looks flat so it can be concluded that it is not influenced by sea tides.

Based on the observational data, tidal analysis was carried out using the **Least Squares method** so that the tidal component results were obtained as can be seen in **Table 2-5** below. The average value at the WL01 or MSL station was at a reading of 3.23 m while the maximum value was 5.78 m and the lowest at 0.13 m.

Table 2-5 Tidal components of Kumbe River

Tidal Component	Amplitude (m)	Phase (°)
MSF	0.027	337.3
O1	0.553	301.8
K1	0.841	42.4
M2	0.821	136.7
S2	0.201	212.4
M3	0.045	178.7
SK3	0.034	233.8
M4	0.023	183.6
MS4	0.053	259.3
S4	0.030	124.5
2MK5	0.011	189.6
2SK5	0.020	23.8
M6	0.027	104.9
2MS6	0.031	250.6
2SM6	0.023	58.8
3MK7	0.016	136.7
M8	0.010	269.1

If the calculated form number (Formzahl) is obtained a value of 1.36 or has a mixed type of tide that tends to double, meaning that the tide occurs twice a day with different heights of the first and second tides, this is clearly seen in **Table 2-4**.

Maro River Water Level

Tidal observations in the Maro River were carried out at three points, namely WL04, WL05 and WL06 with the distribution as shown in **Figure 2-23**. If the distance between observation points on the Kumbe River was calculated, the following results were obtained:

a. Estuary - WL04 = 4,424 meters
b. WL04 - WL05 = 73,869 meters
c. WL05 - WL06 = 63,029 meters

The relationship between water level height in WL04, WL05 and WL06 relative to MSL is shown in the following **Table 2-6** and **Figure 2-22**.

Table 2-6 Relation of WL04, WL05 and WL06 to mean sea level (MSL)

Titik Pengamatan Tinggi Muka Air	KOORDINAT BM				Data Tinggi				
	LAT	LONG	X	Y	Tinggi BM Terhadap MSL	Beda Tinggi BM dan Palem Pasut	Tinggi Palem	Nilai Duduk Tengah Terhadap 0 Palem	Nilai Duduk Tengah Sungai Terhadap MSL
WL04	-8.48	140.38	431773.38	9062688.89	4.101	0.136	10.65	6.919	0.234
WL05	-8.32	140.65	461135.53	9080343.1	3.425	0.082	8	5.502	0.845
WL06	-8.15	140.8	478247.57	9099192.94	6.387	-0.038	9	3.988	1.413

Figure 2-22 Mean water level of river surface at WL 04, 05 and WL06 with respect to MSL

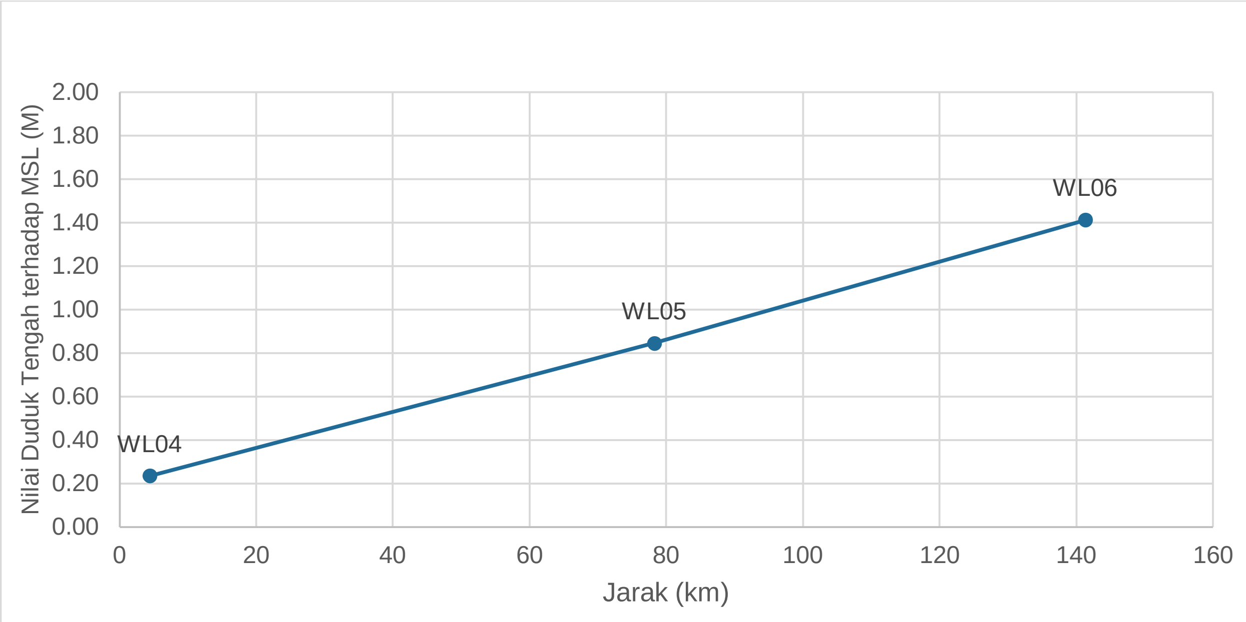


Figure 2-23 Observation of Maro River water level at WL04, WL05 and WL06 relative to MSL

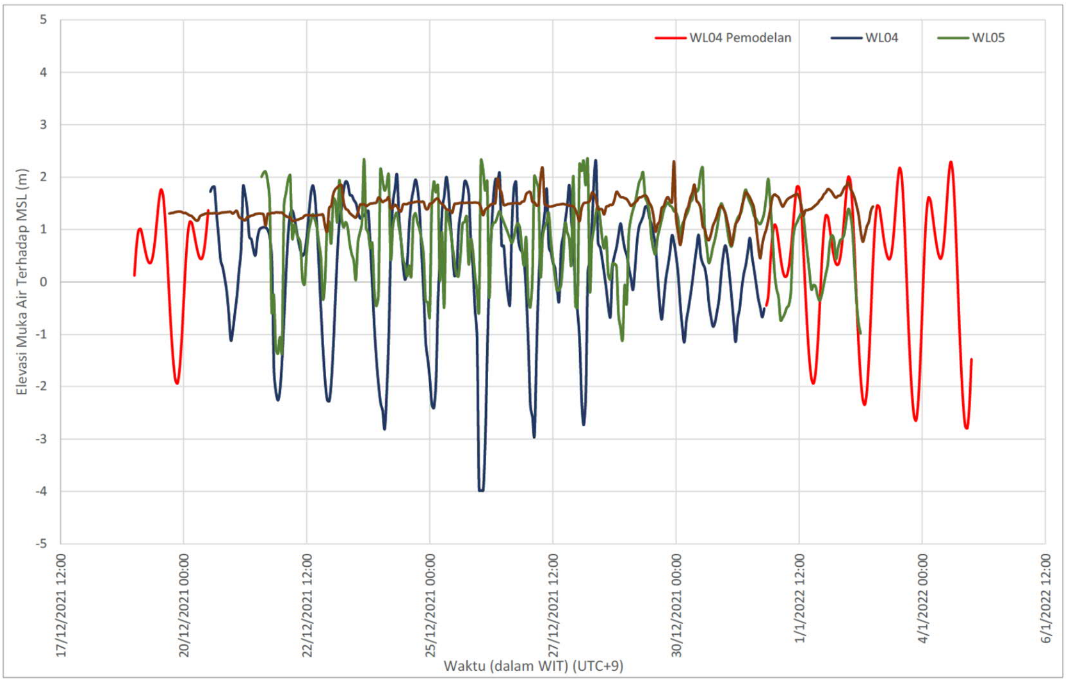
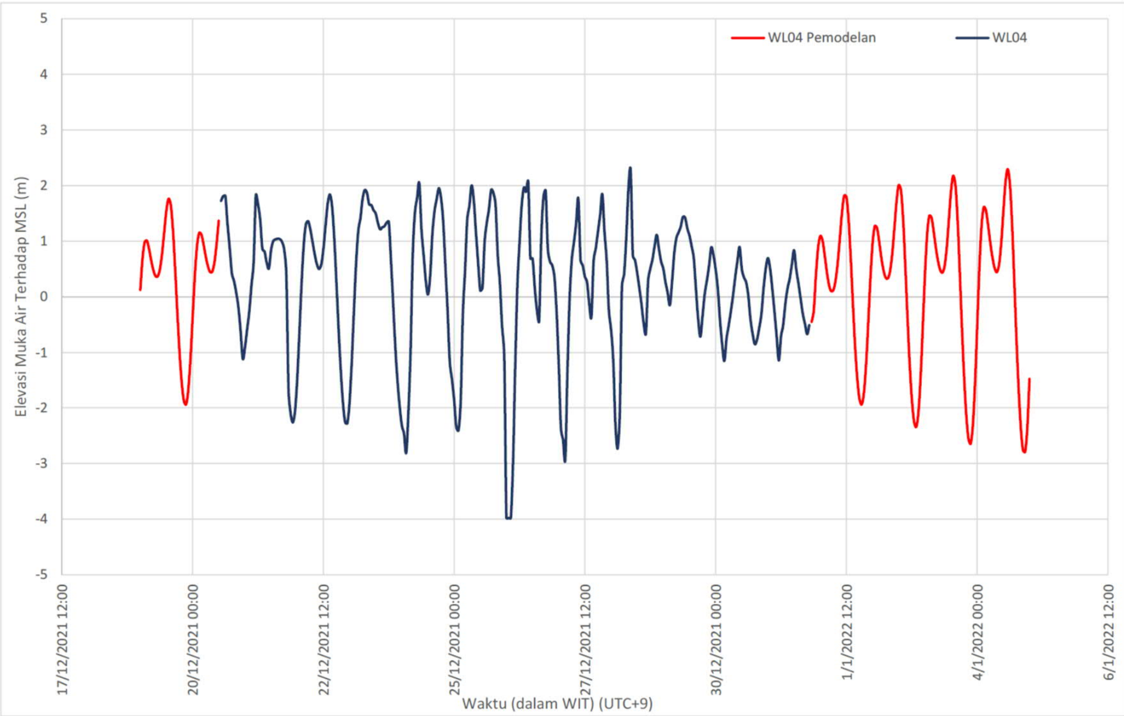


Figure 2-23 in the middle part (WL05) with about 74 km from WL05 it is still influenced by the tide with a tide of about 3 meters. In the upstream (WL06) with about 136 km from WL03, the graph of sea level still seems to fluctuate with a tidal level of about 1-2 meters. This condition is different from the Kumbe River, which no longer experiences tides at 110 km from the downstream. This appears to be because the Maro River is wider than the Kumbe River as well as being flatter so that the tidal effects can still extend inland.

Figure 2-24 Observation of Maro River water level at WL04.



Based on the results, a tidal analysis was carried out using the **Least Squares method** so that the tidal component results were obtained as can be seen in **Tab**le 2-7. The average value at the WL04 or MSL station was 6.92 m reading while the maximum value was 8.98 m and the lowest at 2.70 m.

Table 2-7 Tidal components of Maro River

Tidal Components	Amplitude (m)	Phase (°)
MSF	0.0628	61.70
O1	0.6167	308.74
K1	0.8816	30.70
M2	1.1420	146.44
S2	0.1653	287.91
M3	0.0273	354.37
SK3	0.0653	263.38
M4	0.0459	162.69
MS4	0.0779	312.32
S4	0.0611	177.50
2MK5	0.0101	286.39
2SK5	0.0313	21.96
M6	0.0317	54.56
2MS6	0.0460	315.90
2SM6	0.0412	166.86
3MK7	0.0127	202.18
M8	0.0152	165.17

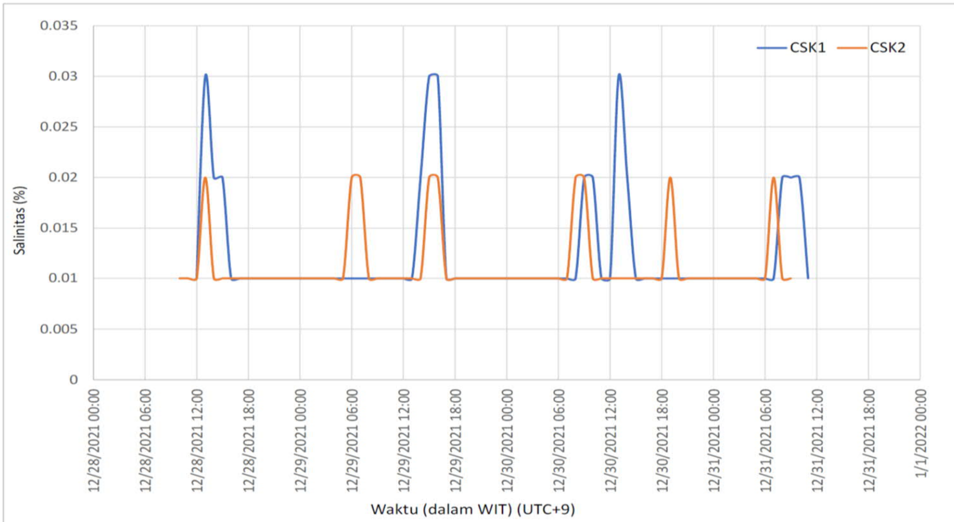
If the calculated form number (Formzahl) is obtained a value of 1.14 or has a mixed tidal type that tends to be double (same as the tidal conditions in the Kumbe River), meaning that the tides occur twice a day with different heights of the first and second tides, this is clearly seen in **Figure 2-24**.

2.5.4 Saline water Intrusion.

Saline water intrusion in the Kumbe River

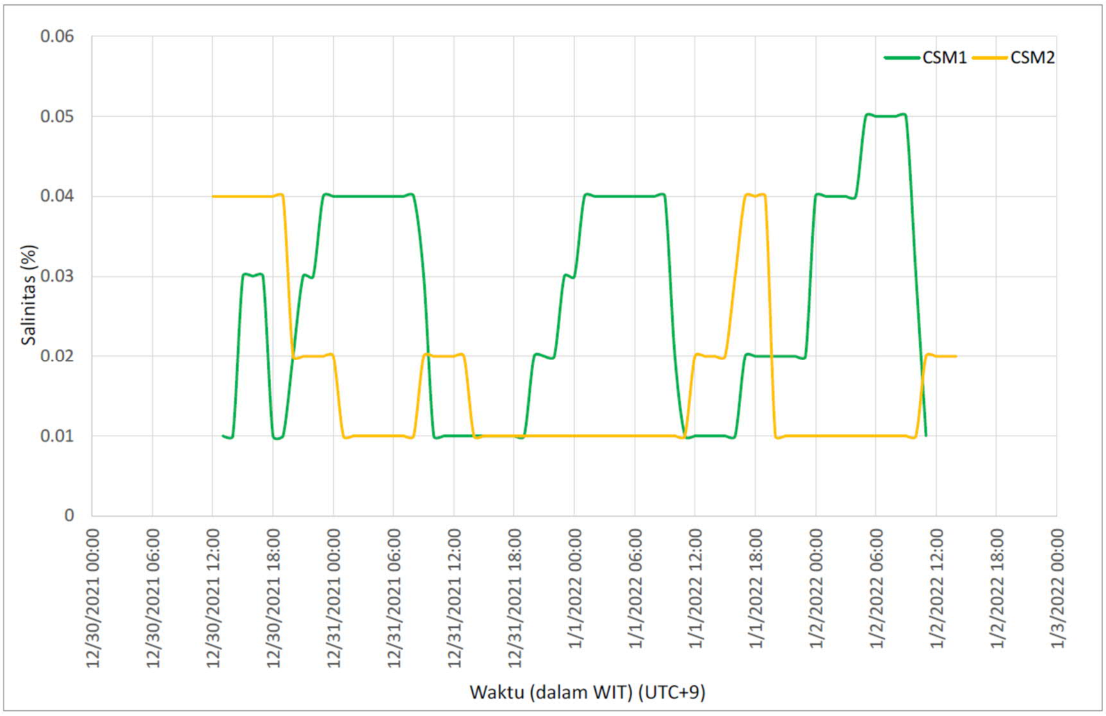
From **Figure 2-25**, it can be said that seawater intrusion reached CSK1, but in CSK2 it was very small. Meanwhile, from the results of the salinity value plot, the variation in the values obtained is not very significant between CSK1 and CSK2, although the salinity value in CSK1 is greater than the salinity in CSK2, so there is an indication that there is a higher salt content in CSK1 compared to CSK2. It is noted that these readings were taken during the wet season.

Figure 2-25 Saline water intrusion in the Kumbe River



From the **Figure 2-26**, it can be said that seawater intrusion reaches CSK1 and CSK2. Meanwhile, from the results of the salinity value plot, the variation in the values obtained is not too significant the difference between in CSM1 and CSM2, although the salinity value in CSM1 is greater than the salinity in CSM2, so there is an indication that there is a higher salt content in CSM1 compared to CSM2.

Figure 2-26 Saline water intrusion in the Maro River



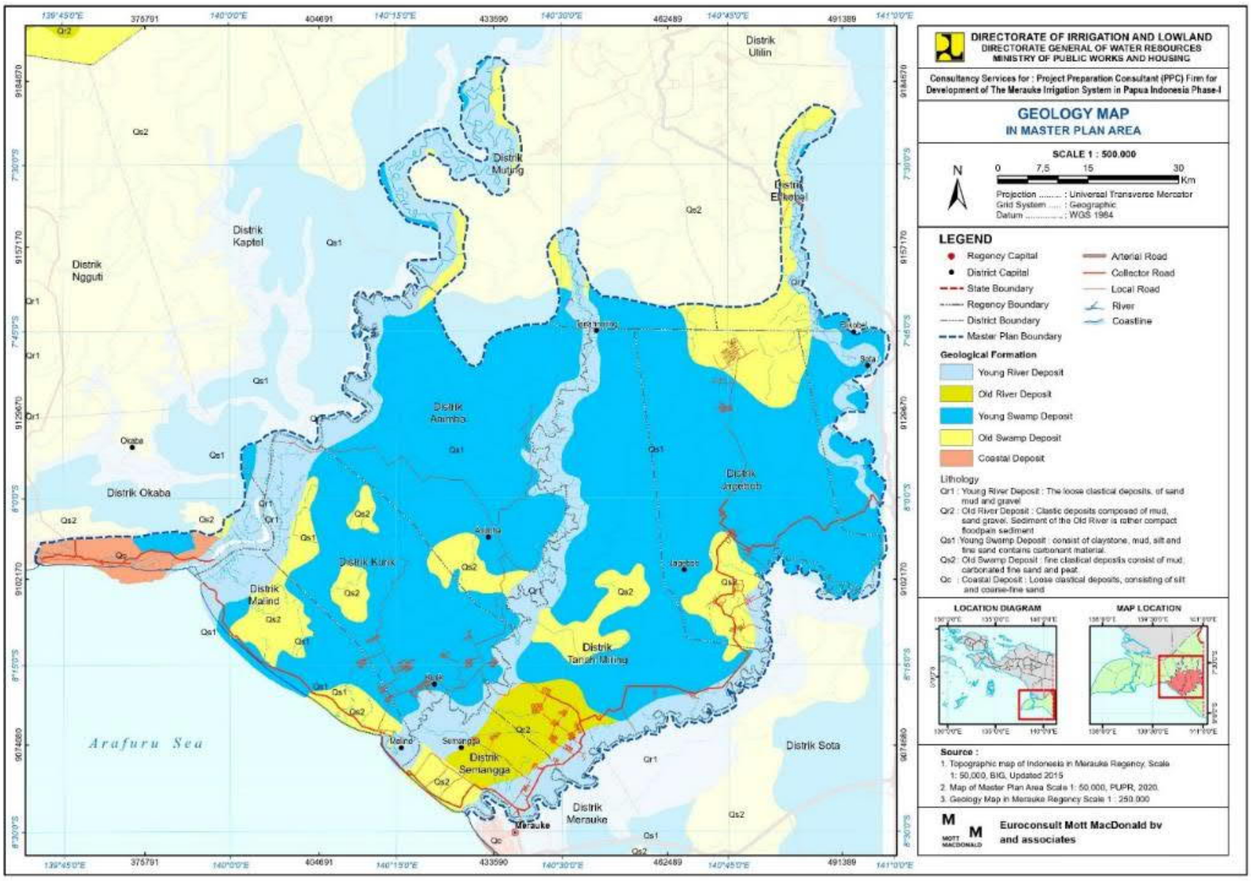
2.6 Geotechnical surveys

2.6.1 Geological conditions

General geology of the Merauke consists of young river deposits, old river deposits, young swamp deposits, old swamp deposits and coastal deposits.

- Young river deposits (Qr1) lithology are loose clastic deposits consisting of sand, mud, gravel
- Old river deposits (Qr2) are clastic deposits composed of mud, sand, gravel. Old river deposits are the result of relatively compact floodplain deposits. The sedimentation of the two rivers above is still ongoing until now.
- Young swamp deposits (Qs1), consisting of an arrangement of claystone, mud, silt and fine sand, containing carbonaceous material. The deposition of this young swamp is still active.
- Old swamp sediment (Qs2), is a fine clastic deposit, consisting of silt and fine carbonaceous sand and peat.
- Coastal deposits (Qc), in general, are loose clastic deposits, fine and coarse consisting of silt and fine-coarse sand.

Figure 2-27 Project area regional stratigraphy

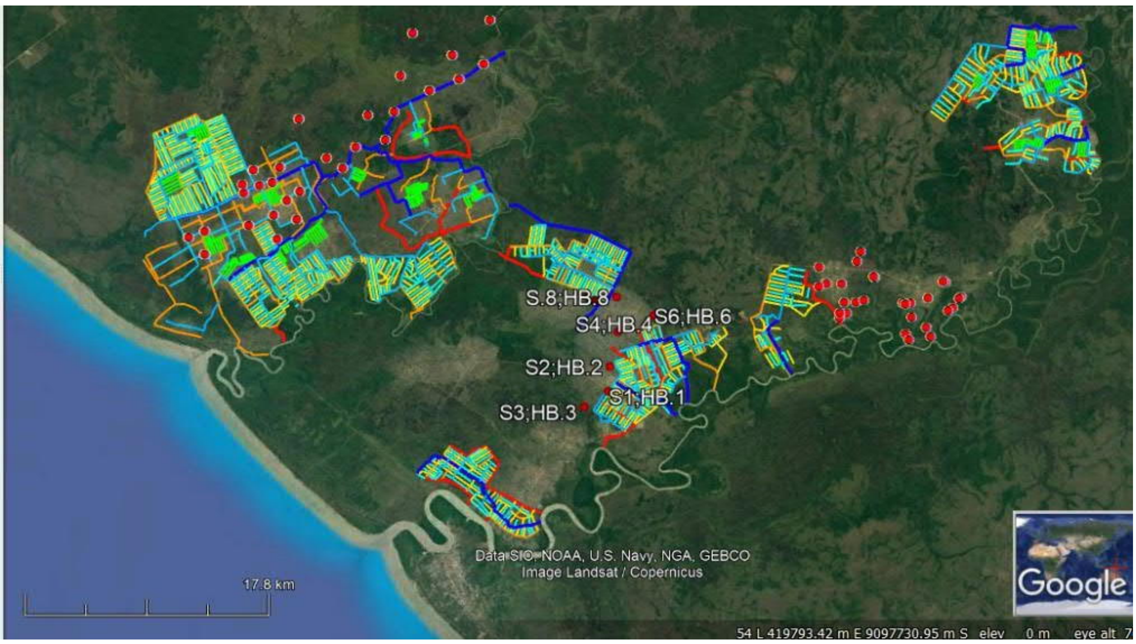


Source: Geologi ESP-Merauke Report

2.6.2 Previous studies

In the Merauke irrigation area, several investigations of soil mechanics have been carried out for the purposes of detailed design of irrigation development in several areas, as presented in the map below.

Figure 2-28 Previous SI site map (Red dot)-and detailed location of the Merauke ESP design



Locations of the points of previous ground investigations are marked with red dots, while the Merauke ESP work area is depicted with coloured lines. The results of previous investments are presented in a summary as follows:

Previous studies have been carried out in Merauke district, including in the following locations:

1. **DIR Sermayam, Detailed work of Sermayam Swamp Irrigation Design, Merauke District, Merauke Province, 2020 by PT. Citra Cipta Consultant.**

   From the soil investigation, the Review of Design for the Development of the Sermayam Erom Irrigation Area in Merauke District and the results of laboratory tests on the tested soil samples, it can be concluded as follows:

   - The surface soils in the study spots were found to have similar soil types in the form of clay silt – silty loam, at a deeper elevation containing sand with a soft to clay consistency, dominated by grey colour, high plasticity, soil class MH, CH, ML and CL. The thickness of the soil layer is assumed to be > 2 m, conical pressure qc = 10 - 45 kg/cm2.
   - Up to the final drilling depth (0-2 m) at all drill points, generally no groundwater level has been found.
   - To carry heavy loads, it is recommended to use a deep foundation whose ends support a hard layer of soil.

2. **Review of the Kurik irrigation area design in Merauke District in 2020, by PT. Ramadayani Mitramulya.**

   From the results of sondir (14 points), hand drill (14 points hand drill), in the field as well as a visual review of the soil samples that have been carried out, it can be described as follows;

   - At some points, hard soil was found at a depth of about 12.00 meters only at sondir point number 06 with Qc = 40 Kg/cm2, while at other points at a depth of < 12 m, Qc was obtained > 40 kg cm/2.
   - The general lithology of the area under study is fine-grained soil; reddish-brown colour; very cohesive; Silty Clay (CL - ML)

3. **SID Semangga Detailed Design work for the Semangga Swamp Irrigation Area and Tanah Miring, by PT. Teraga Olahrakayasa, Jayapura. 2015.**

   According to the results of laboratory tests on the sample, the following information is obtained:

   - Specific gravity: 2.63 – 2.65 g/cm3
   - Dry Density: 1.49 – 1.50 g/cm3
   - Porosity: 51.44 – 53.15%
   - Atterberg Limit (%): LL : 29.82 – 30.71; OT : 11.41 – 12.91; PI : 18.41 – 18.80
   - Grain size analysis: Sand: 1.50 – 1.88%; Silt: 15.65 – 17.39 %; Clay: 80,80 82,42 %
   - Consolidation test: Cc = 0.59 – 0.61;
   - Permeability: 1.48E-07 – 1.57E07 cm/s; Cw = 1.10E-03 – 1.17E-03
   - Triaxial test: '(degree): 7˚ 27'0' - 6˚ 57' 0'; c' (kPa) = 2.00-2.23
   - The content of the fractions can be described as follows: The dominant fraction is 67% clay fraction, 20% dust fraction and 13% sand fraction.

4. **DIR Wapeko, Detail Design of Wapeko Swamp Irrigation Area Merauke District: Year 2020 by PT. Bhawana Prasata, Bandung, West Java.**

   14 sondir points and 14 hand drill points with the following conclusions:

   - Work area based on Geological Map Sheet Merauke, Irian Jaya, Scale 1: 250,000, by R. Heryanto and H. Panggabean (Center for Geological Research and Development, 1995), Quaternary Holocene

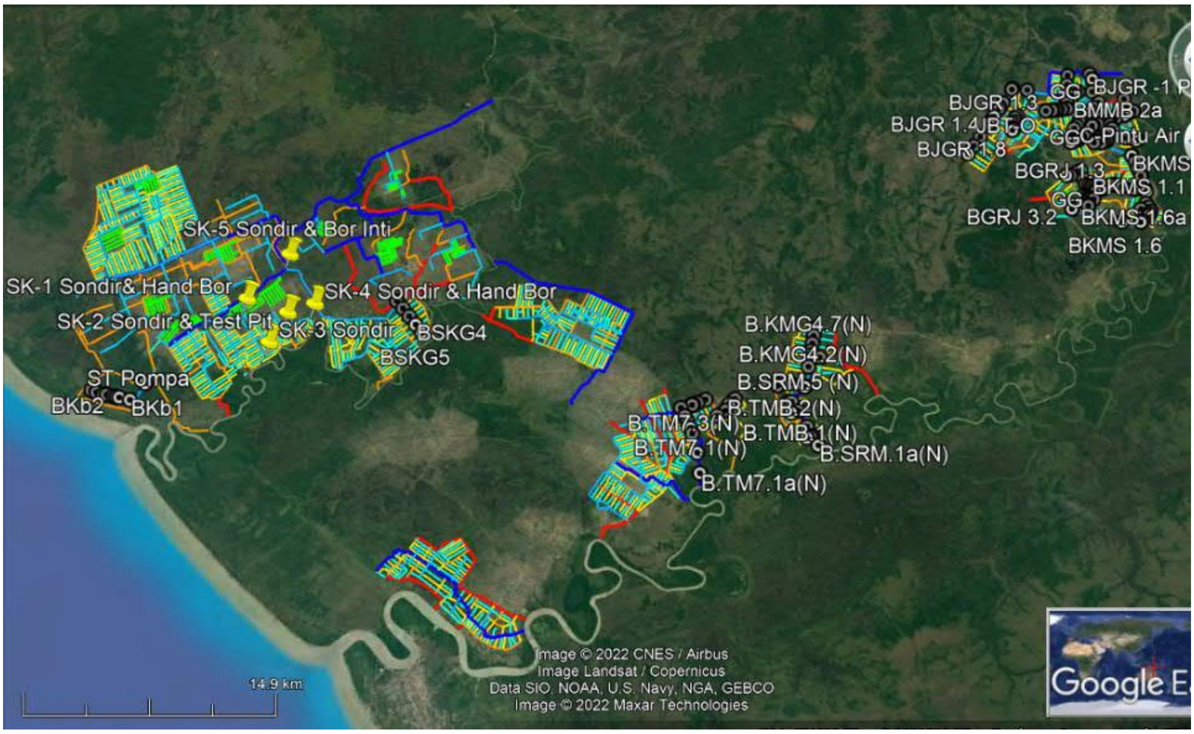
- The morphology of the work area occupies a plain morphology unit
- The local ground water level (MAT) ranges from 0.00 – 2.00 m
- The bearing capacity of the soil from the test results of 14 sondir points for deep foundations is 20.35 tons/m2 – 55.502 tons/m2.
- Soil bearing capacity for shallow foundations based on laboratory test results from the results of 14 hand drill points ranges from 11,119 tons/m2 – 36,167 tons/m2.
- Considering the condition of the bearing capacity of the soil at the survey location, the appropriate type of foundation is shallow foundation. The dimensions and types of foundations that will be applied must be adjusted to the conditions of the upper structure on the ground.
- As for the construction of heavy buildings, a foundation in the type of well foundation is required which rests on the bedrock (hard layer).

From the results of previous studies, it can be seen that the Merauke area is dominated by clay, silt and a small amount of fine sand. The soil bearing capacity at the study site appears to be quite stable, this can be seen from the condition of the buildings that have been built for a long time, showing that the condition is still quite stable, not experiencing a significant decline or change in position.

5. **Investigation carried out by ESP- Merauke**

The location of the geotechnical investigation for the Merauke ESP project is carried out at the following locations: Salor Kampung, Kumbe kampung, New Sermayam and Lower Jagebob. This is presented in the map as follows:

Figure 2-29 Geotechnical investigation location



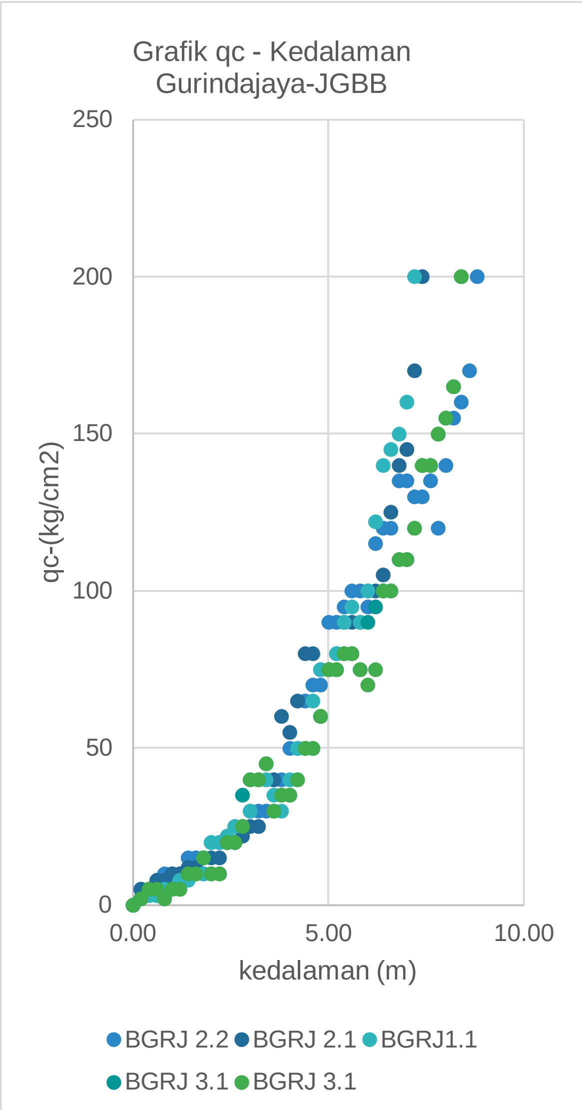
These locations are the locations of new irrigation areas that have not been investigated in previous studies. This is due to the limited time available, so it is carried out only at that location. The soil conditions at the Merauke ESP investigation location are relatively not too different from previous local investigation, so that the data obtained is still relevant enough to be used as a basis for planning, especially on foundation structures.

From the results of the field investigations that have been carried out, the following results are obtained:

From the hand drill data, the average groundwater level is < 1 m, this is in accordance with the time of drilling in January 2022 during the rainy season, and the water level around the location is quite high. From the logging data from hand drills in Lower Jagebob, it appears that top soil is dominated by black-brown clay or silt at a depth of 0-0.2 m, and clay or silt of grey to reddish yellow colour and gravel at a depth of 0.2 – 1.00. 1-2 m deep in the form of red clay. For Kumbe Kampung, a depth of 0-0.2 is top soil, clay or yellowish black silt, 0.2 – 2 m in the form of clay or yellow silt. Based on the results of the vane shear test at Kumbe to a depth of 2 m, soils were obtained in the sensitive to very sensitive category. Meanwhile in Sermayam 0-0.6 topsoil is clay or silt containing reddish-coloured gravel, 0.6-0.8 is clay or reddish-brown silt, and 0.8-2.0 m is clay or silt containing coloured gravel. redness. With the category of not sensitive to very sensitive. For Sermayam 0-1.4 m is top soil in the form of clay or brownish black silt which is very sensitive, 1.4-2 m of clay or yellowish silt and very sensitive. For Kurik Harapan 0-1.4 m in the form of black clay or silt in the sensitive category and 1.4-2 m in the form of blackish and sensitive clay.

Based on the data from the sondir test results obtained in the form of a graph as follows:

Figure 2-30 qc-Gurindajaya, Jagebob Raya depth



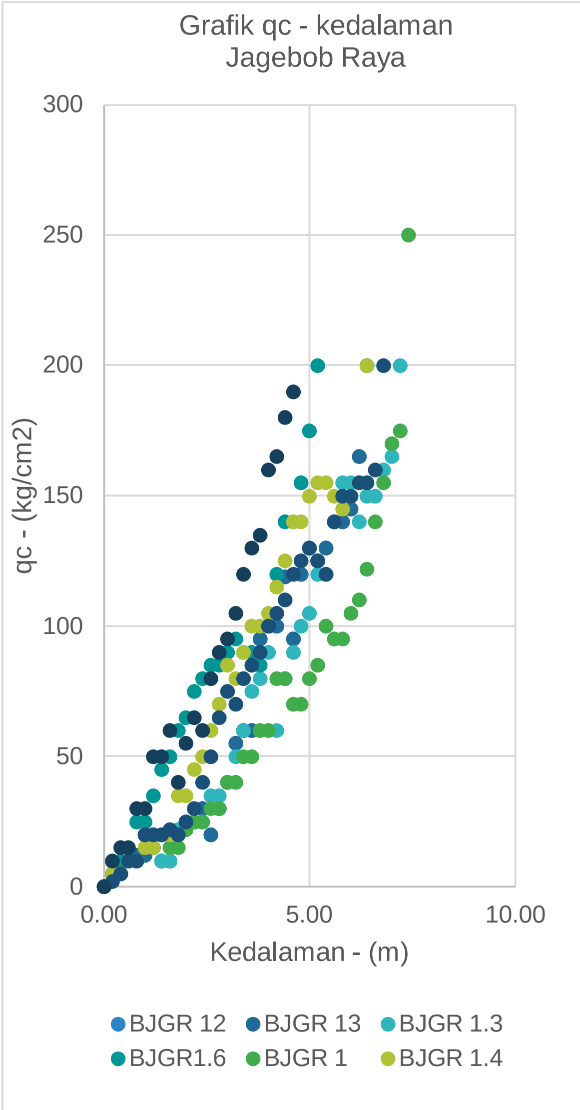


Figure 2-31 qc-Kamnosari-Lower Jagebob depth

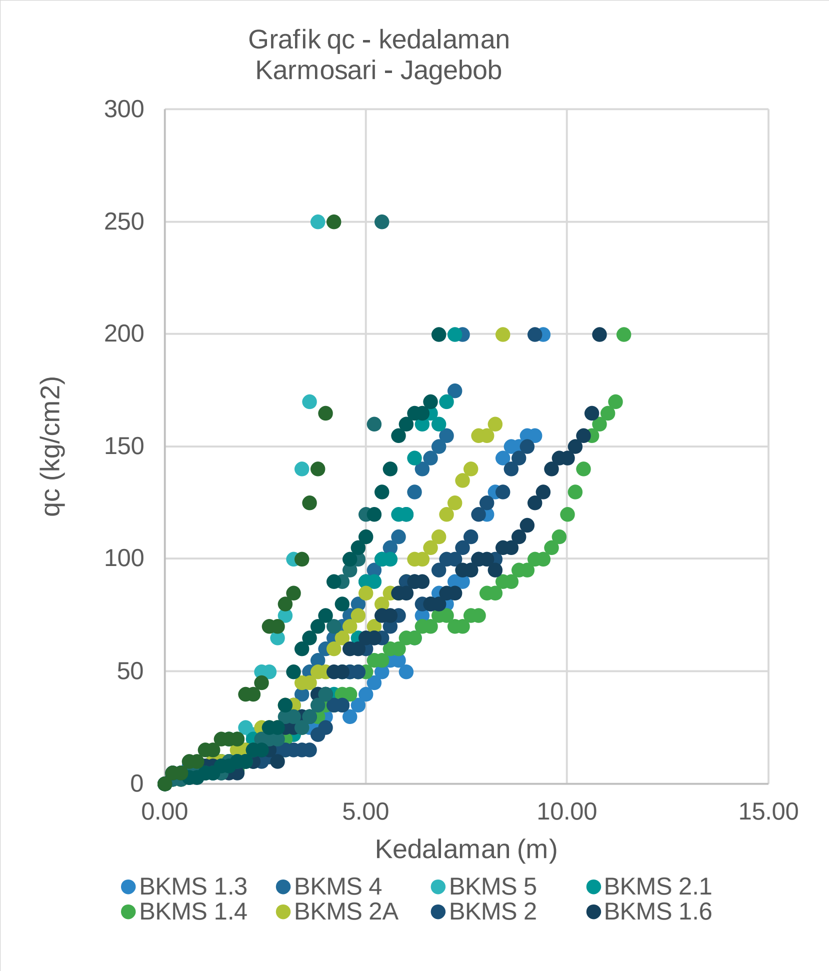


Figure 2-32 qc-Kumbe kampung depth

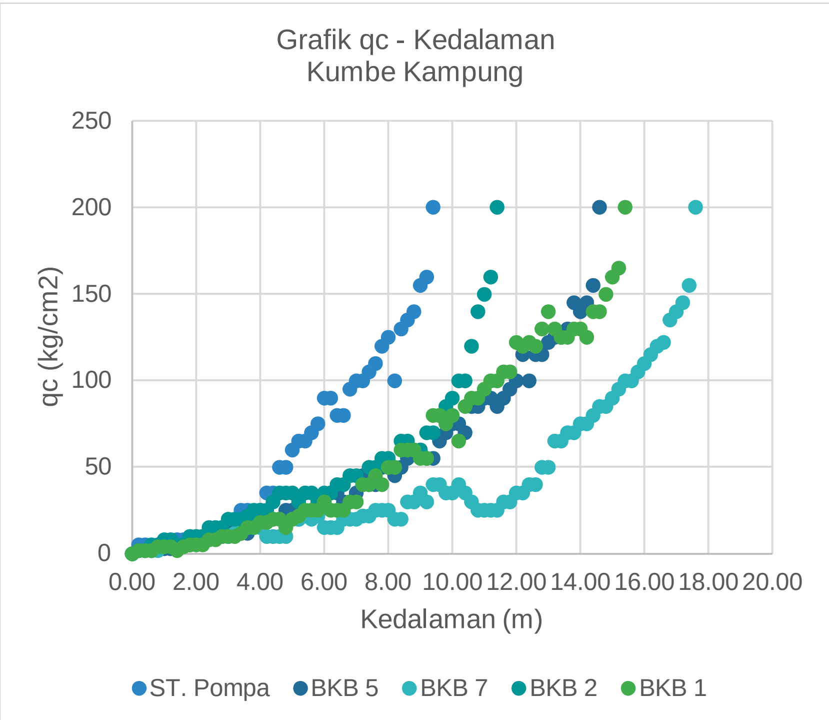


Figure 2-33 qc-Mimi Baru-Lower Jagebob depth

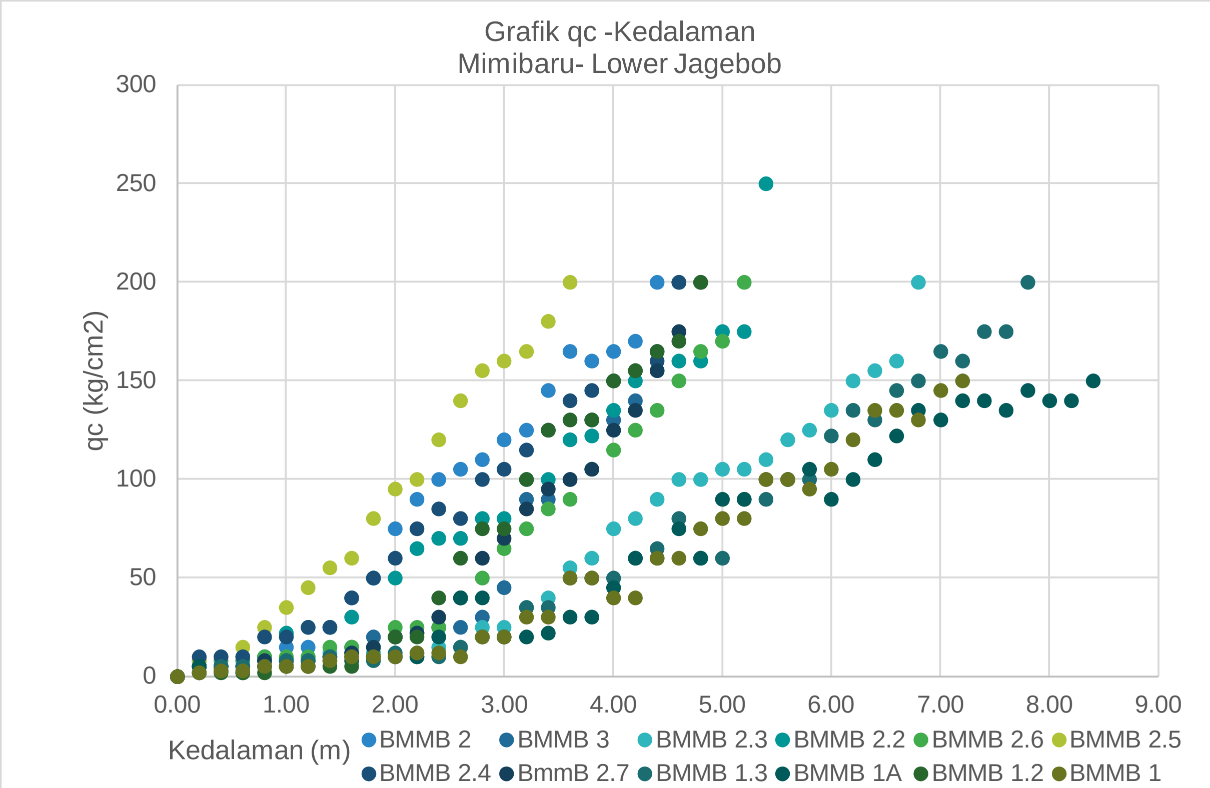


Figure 2-34 qc-Mimi Baru-Jagebob Sluice gate

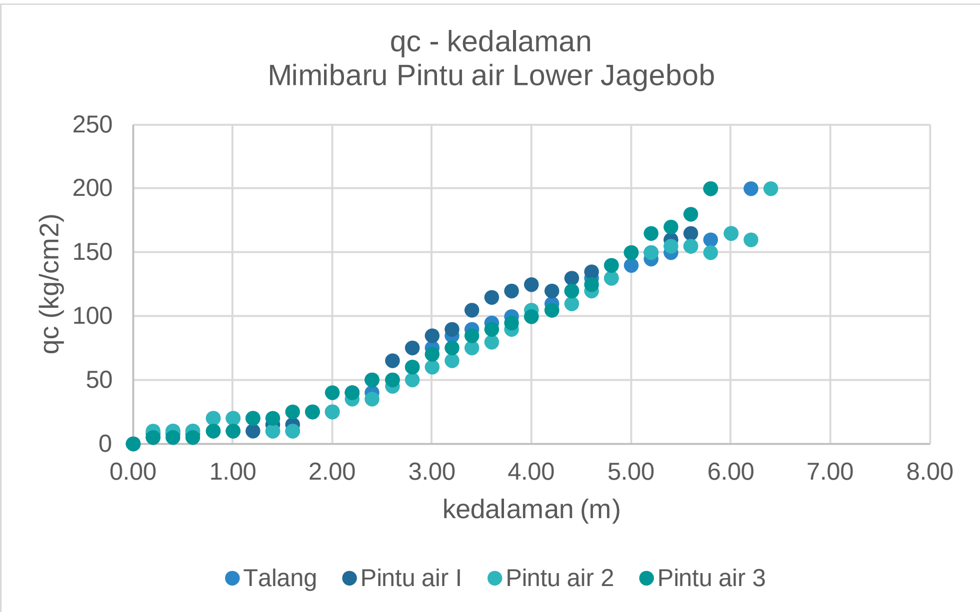
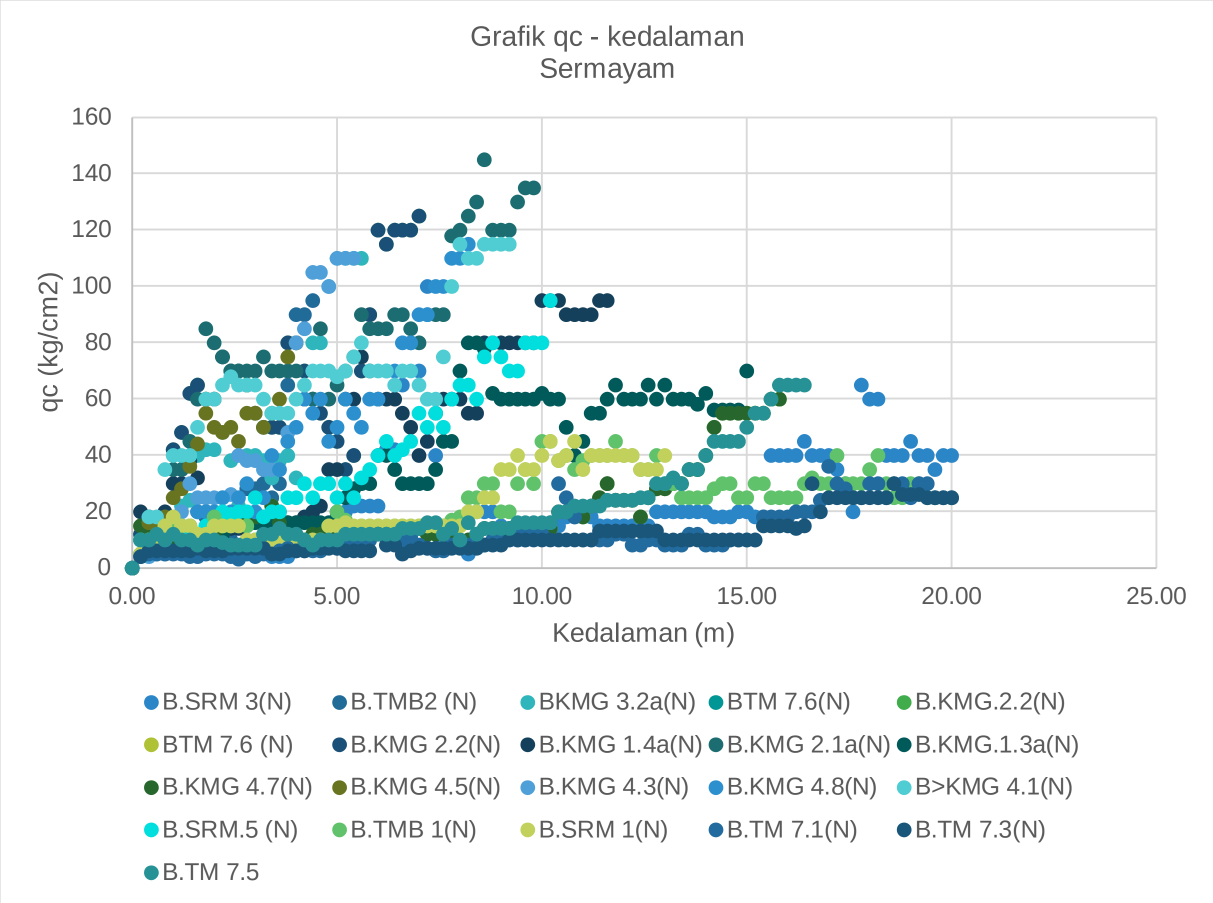


Figure 2-35 qc- Sermayam depth



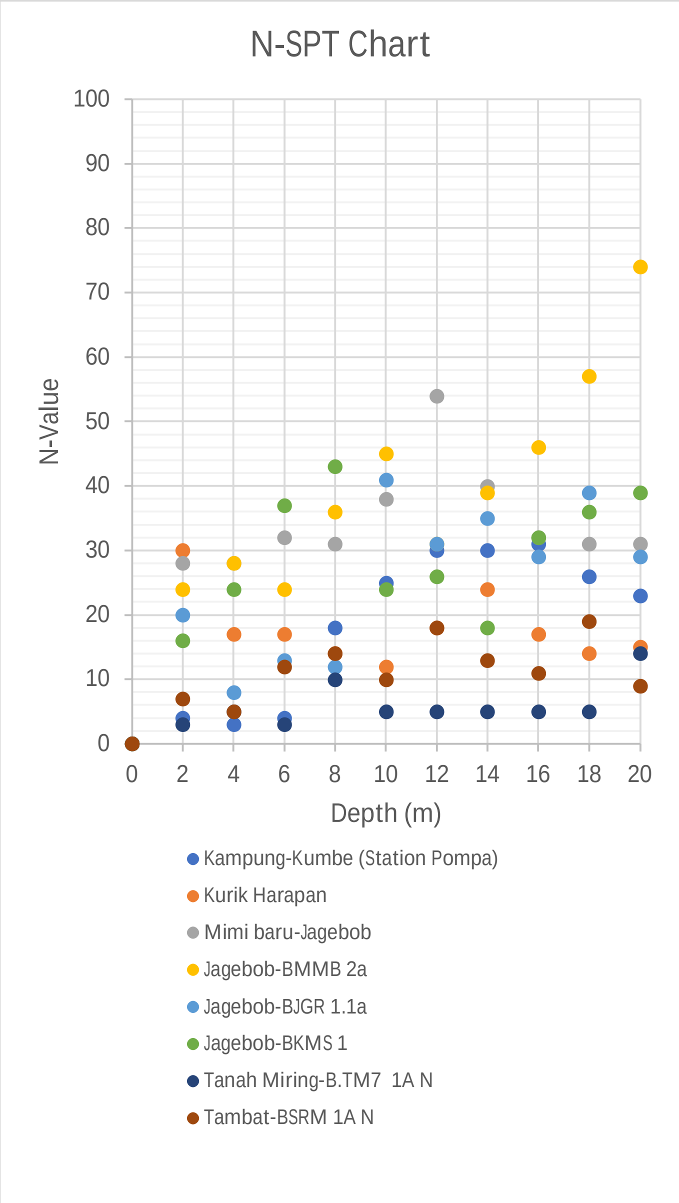
Based on sondir data, the soil bearing capacity according to the field qc value is as follows:

Table 2-8 Soil bearing capacity

kedalaman	qc	Tanah tak Berkohesi (qult(kg/cm2))		qall (Kg/cm2		Tanah berkohesi (qult(kg/cm2))		qall(kg/cm2)		qall (ton/m2)	
(m)	(kg/cm2)	Lajur	Bujur Sangkar	Lajur	Bujur Sangkar	Lajur	Bujur Sangkar	Lajur	Bujur Sangkar	Lajur	Bujur Sangkar
		qult=28-0,0052*((300-qc)^1,5)	qult=48-0,009((300-qc)^1,5)	Qult/3	Qult/3	qult = 2 + 0,28 qc	qult= 5 + 0,34 qc	qult/3	qult/3	qult/3	qult/3
	0	0,98	1,23	0,33	0,41	2	5	0,67	1,67	6,67	16,67
	1	1,11	1,47	0,37	0,49	2,28	5,34	0,76	1,78	7,60	17,80
	2	1,25	1,70	0,42	0,57	2,56	5,68	0,85	1,89	8,53	18,93
	3	1,38	1,93	0,46	0,64	2,84	6,02	0,95	2,01	9,47	20,07
	4	1,52	2,17	0,51	0,72	3,12	6,36	1,04	2,12	10,40	21,20
	5	1,65	2,40	0,55	0,80	3,4	6,7	1,13	2,23	11,33	22,33
	6	1,79	2,63	0,60	0,88	3,68	7,04	1,23	2,35	12,27	23,47
	7	1,92	2,86	0,64	0,95	3,96	7,38	1,32	2,46	13,20	24,60
	8	2,05	3,09	0,68	1,03	4,24	7,72	1,41	2,57	14,13	25,73
	9	2,19	3,32	0,73	1,11	4,52	8,06	1,51	2,69	15,07	26,87
	10	2,32	3,55	0,77	1,18	4,8	8,4	1,60	2,80	16,00	28,00
	11	2,45	3,78	0,82	1,26	5,08	8,74	1,69	2,91	16,93	29,13
	12	2,58	4,01	0,86	1,34	5,36	9,08	1,79	3,03	17,87	30,27
	13	2,72	4,24	0,91	1,41	5,64	9,42	1,88	3,14	18,80	31,40
	14	2,85	4,47	0,95	1,49	5,92	9,76	1,97	3,25	19,73	32,53
	15	2,98	4,70	0,99	1,57	6,2	10,1	2,07	3,37	20,67	33,67
	16	3,11	4,93	1,04	1,64	6,48	10,44	2,16	3,48	21,60	34,80
	17	3,24	5,15	1,08	1,72	6,76	10,78	2,25	3,59	22,53	35,93
	18	3,37	5,38	1,12	1,79	7,04	11,12	2,35	3,71	23,47	37,07
	19	3,51	5,61	1,17	1,87	7,32	11,46	2,44	3,82	24,40	38,20
	20	3,64	5,83	1,21	1,94	7,6	11,8	2,53	3,93	25,33	39,33
	21	3,77	6,06	1,26	2,02	7,88	12,14	2,63	4,05	26,27	40,47
	22	3,90	6,28	1,30	2,09	8,16	12,48	2,72	4,16	27,20	41,60
	23	4,03	6,51	1,34	2,17	8,44	12,82	2,81	4,27	28,13	42,73
	24	4,16	6,73	1,39	2,24	8,72	13,16	2,91	4,39	29,07	43,87
	25	4,29	6,96	1,43	2,32	9	13,5	3,00	4,50	30,00	45,00
	26	4,42	7,18	1,47	2,39	9,28	13,84	3,09	4,61	30,93	46,13
	27	4,54	7,40	1,51	2,47	9,56	14,18	3,19	4,73	31,87	47,27
	28	4,67	7,63	1,56	2,54	9,84	14,52	3,28	4,84	32,80	48,40
	29	4,80	7,85	1,60	2,62	10,12	14,86	3,37	4,95	33,73	49,53
	30	4,93	8,07	1,64	2,69	10,4	15,2	3,47	5,07	34,67	50,67
	31	5,06	8,29	1,69	2,76	10,68	15,54	3,56	5,18	35,60	51,80
	32	5,19	8,51	1,73	2,84	10,96	15,88	3,65	5,29	36,53	52,93
	33	5,31	8,73	1,77	2,91	11,24	16,22	3,75	5,41	37,47	54,07
	34	5,44	8,96	1,81	2,99	11,52	16,56	3,84	5,52	38,40	55,20
	35	5,57	9,18	1,86	3,06	11,8	16,9	3,93	5,63	39,33	56,33
	36	5,69	9,39	1,90	3,13	12,08	17,24	4,03	5,75	40,27	57,47
	37	5,82	9,61	1,94	3,20	12,36	17,58	4,12	5,86	41,20	58,60
	38	5,95	9,83	1,98	3,28	12,64	17,92	4,21	5,97	42,13	59,73
	39	6,07	10,05	2,02	3,35	12,92	18,26	4,31	6,09	43,07	60,87
	40	6,20	10,27	2,07	3,42	13,2	18,6	4,40	6,20	44,00	62,00
	41	6,33	10,49	2,11	3,50	13,48	18,94	4,49	6,31	44,93	63,13
	42	6,45	10,70	2,15	3,57	13,76	19,28	4,59	6,43	45,87	64,27
	43	6,58	10,92	2,19	3,64	14,04	19,62	4,68	6,54	46,80	65,40
	44	6,70	11,14	2,23	3,71	14,32	19,96	4,77	6,65	47,73	66,53
	45	6,83	11,35	2,28	3,78	14,6	20,3	4,87	6,77	48,67	67,67
	46	6,95	11,57	2,32	3,86	14,88	20,64	4,96	6,88	49,60	68,80
	47	7,07	11,78	2,36	3,93	15,16	20,98	5,05	6,99	50,53	69,93
	48	7,20	12,00	2,40	4,00	15,44	21,32	5,15	7,11	51,47	71,07
	49	7,32	12,21	2,44	4,07	15,72	21,66	5,24	7,22	52,40	72,20
	50	7,45	12,42	2,48	4,14	16	22	5,33	7,33	53,33	73,33

Based on the N-SPT data from the core drill, the following results were obtained:

Figure 2-36 N-SPT graph

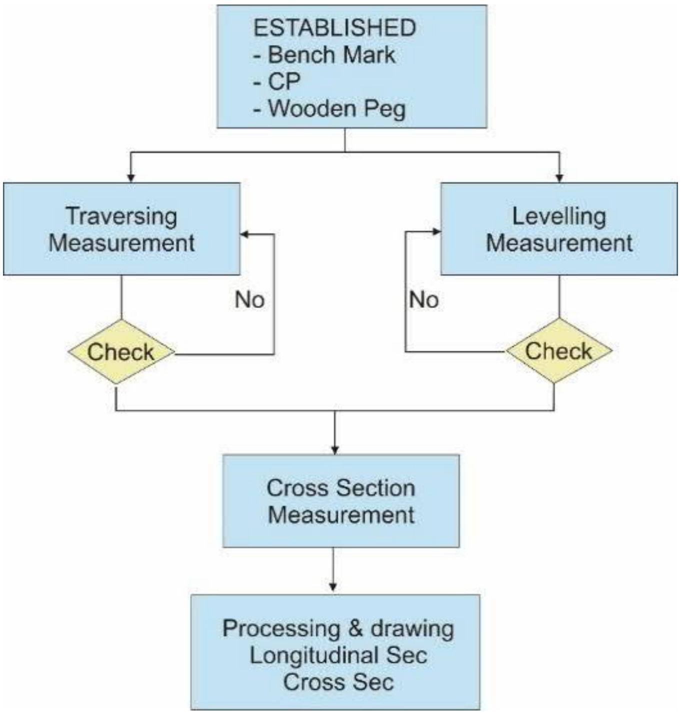


From the SPT- data, it can be seen on Tanah Miring B.TM7 1A (N) obtained N-SPT < 10 to a depth of 18 m, while in other locations for depths >10 m, N-SPT > 10. However, overall N-SPT is up to a depth of 20 m < 40, except for some in Jagebob > 40.

2.7 Main and secondary canal surveys

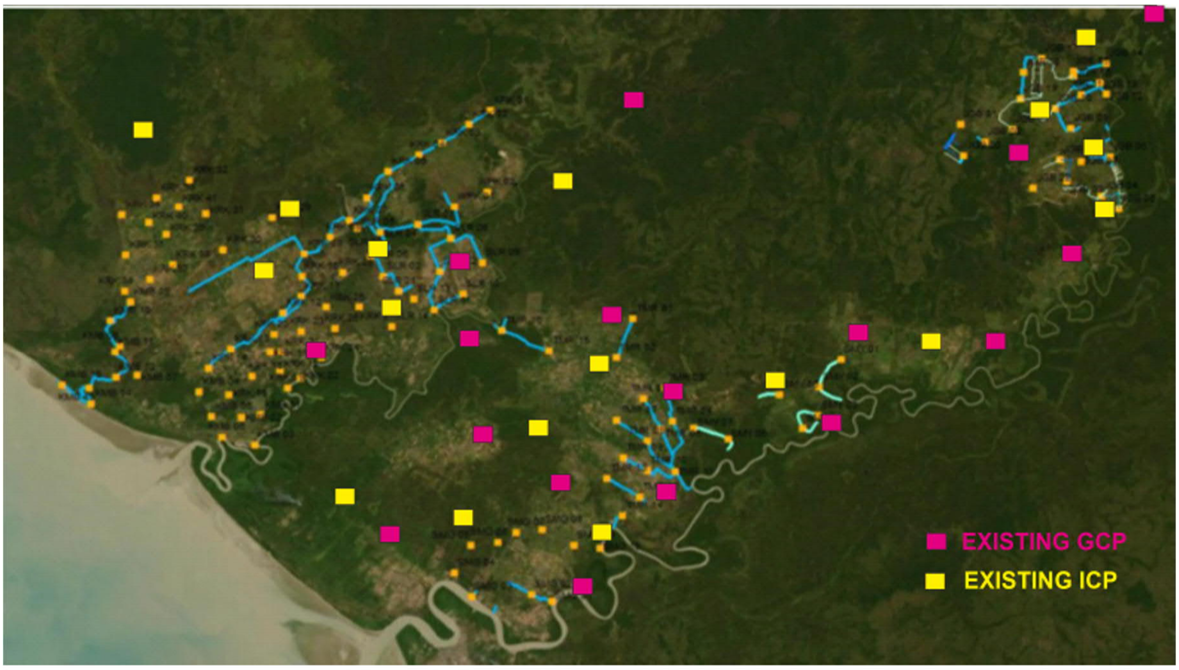
1. Work Flow

Figure 2-37 Work Flow of Canal Survey



2. Survey Area

Figure 2-38 Survey Area



3. Establish Control point

General Specification of Benchmark (BM) are as follows:

- All measurements of coordinates (x,y) and height (z) must be referred to a fixed point
- The density of each control point represents an area of ±250 ha or every 2.5 km distance along the canal
- The number of Benchmark must cover all the area to be mapped.
- Benchmark is installed before field work
- There are 2 kinds of benchmarks that must be installed, namely Bench Mark and Control Point. Both of them, must be visible to each other because it will be used as azimuth.

Figure 2-39 Construction of Bench Mark and Control Point

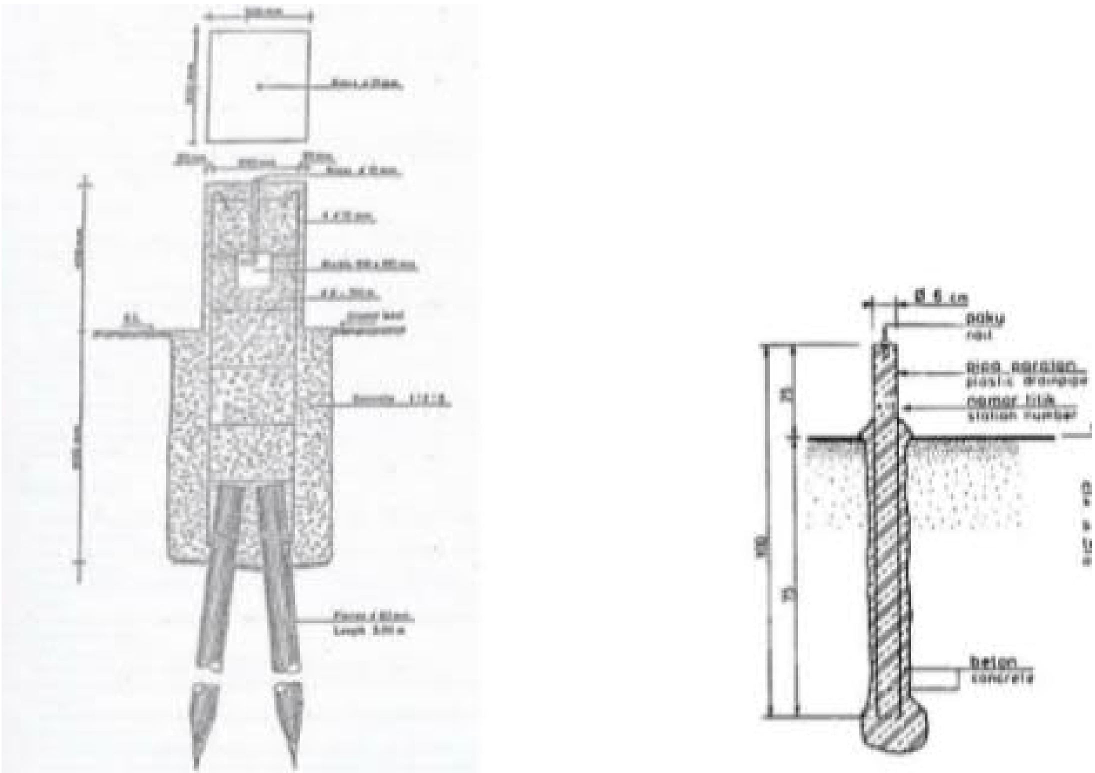


Figure 2-40 Preparation for established Control Point

Figure 2-41 Bench Mark and Control Point have established

4. Measurement Method

a. GPS Observation

All of Bench Mark and CP must be measured in coordinates (x,y) and height (z) by using Total Station and or GPS and Automatic Levelling.

In observing the GPS carrier phase, a relative positioning model will be used to determine the base line between two points. In observing GPS satellites there are several things that must be considered:

1. Elevation angle (angle to horizon) of the captured satellite is at least 15 degrees.
2. GPS data recording is performed every 15 seconds (time between epochs)
3. In one observation session a minimum of 6 satellites.
4. In the observation session the GDOP value is not more than 8
5. Adequate atmospheric and ionospheric conditions
6. The data for each observation session is downloaded and stored in the flash disk or external hard disk recording media.
7. GPS data collection Control points and check points are carried out on a net basis.
8. Planned distribution of control point locations will be made on top of the image blow up;
9. Observation time for determining control points using satellite-based positioning technology is 1 hour or more, if possible JRSP/CORS can be utilized;
10. GPS data collection Control points and check points on a net are carried out per session with a minimum of 3 devices performing GPS data collection simultaneously for each session;
11. If within 10 km from the work area there is no TDT or Geodetic Control Point, then you must create a new Control Point that is tied to TDT order 2, or TDT order 3 BPN or Geodetic Control Point Order 1 Geospatial Information Agency;

GPS data collection session is an interval of data collection in which the base station collects data simultaneously with the rover receiver. The implementation of GPS data collection at a GCP point will generally consist of several data collection sessions.

The timing of GPS data collection should take into account the following factors: number of observable GPS satellites, strength of the satellite geometry, ionospheric activity, activity at the point location and its surroundings (traffic, human and animal traffic), point accessibility and duration of movement between points.

The duration of GPS data collection to be carried out should take into account the following factors: the accuracy of the desired position, the distance between the base station and the rover, the number of satellites observed, the strength of the satellite geometry, the accessibility of the point and the time of movement between points. For GPS observations of each GCP point, the epoch interval used is 3 seconds with the mask angle used is 10° or 15°. The duration of GPS data collection at each GCP point can be seen in the table below.

Figure 2-42 Duration Time for GPS Observation

Jumlah Satelit (GDOP = 8)	Jarak Base Station dan Rover (Km)	Metode Pengamatan	Periode Pengamatan Single Frekuensi	Periode Pengamatan (L1 dan L2)	Jumlah Data (interval epoch 3 detik)
4 atau 5	0 – 5	Static	30 menit	15 menit	300
4 atau 5	5 – 10	Static	50 menit	25 menit	500
4 atau 5	10 – 30	Static	-	60 menit	1200
4 atau 5	30 – 50	Static	-	120 menit	2400

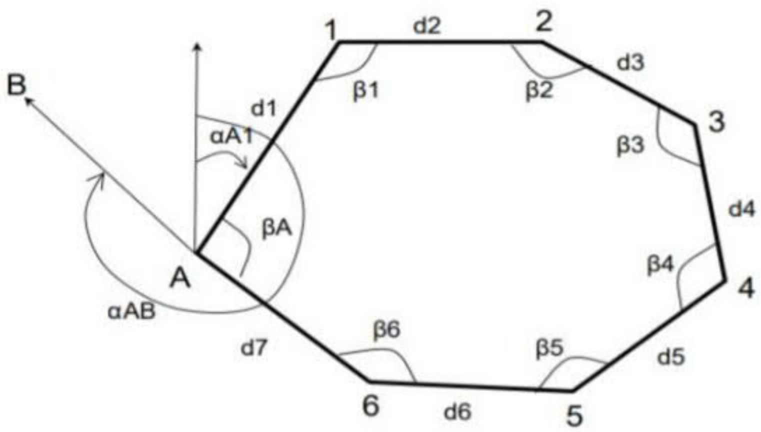
(sumber : Abidin, H. Z., 2001)

The traversing measurements in this activity consist of the main traversing and branch traversing will be started after obtain GPS result.

Maximum distance between traversing points is 100m. Traversing angles are measured with a total station. The accuracy of angle not more than 10 √ n (n = number of polygon points), and an azimuth error of not more than 5 seconds, and accuracy of distance of not more than 20mm √ D (D=Distance (Km)), therefore the total station used is a Total Station type with a maximum angle of accuracy of 5”.

b. Traversing Measurement

Figure 2-43 Circuit Traversing



If we use the Circuit Traversing, the Geometrical Requirement must be :

Angle Requirement

$\sum\beta = (n-2).180 + fs$ if we measure the inside angle

$\sum\beta = (n+2).180 + fs$ if we measure the outside angle

Coordinates Requirement

$\sum d \sin \alpha = 0$
$\sum d \cos \alpha = 0$

Linear Accuracy

$$TL = \frac{\sqrt{(fx2 + fy2)}}{\sum D} \; ; \; fL = \sqrt{fx2 + fy2}$$

Traverse Measurement Standard

- The traverse is a closed loop or Open
- The Tribrach placed on stable soil to obtain accurate horizontal angle and distance observations.
- The Total Station in good condition and their settings have checked continuously during the observation, collimation less than 1 '(one minute).
- The Total Station able to measure up to 1” (one second) and be equipped with the necessary components.
- The position of level bubble and optical clips shall be checked frequently.
- The horizontal angle and distance measurements at least 2 observations
- (FL) for backward target reading
- (FL) for forward target reading
- (FR) for forward target reading
- (FR) for backward target reading

Accuracy:

All observations are reduced in the field if the difference between the four angle values obtained (2FL, 2FR) exceeds 5”, it must be re-measured.

The tolerance for angle closure error is 10 √ n where n is the number of angles, if the tolerance is exceeded, the angles measurement must be repeated and checked.

The linear closure error of the main polygon should not be greater than 1: 10,000 of the total length

5. Levelling survey

For height measurement

- Measurements target reading is using metric measuring tools and sign mats made of metal.
- 2Each equipment have checked for collimation (crossing line error) every day using 2 peg tests, mid-base or similar methods up to a distance of 100 m. Tolerance of collimation error is less than 0.05 mm/m. The level box and automatic compensator should also be checked regularly.
- The double-stand method of measuring flatness is not permitted, the shooting distance is not allowed to be more than 50 m.
- The reading shall not exceed 20 cm from the lower limit and from the upper limit of the measurement target.

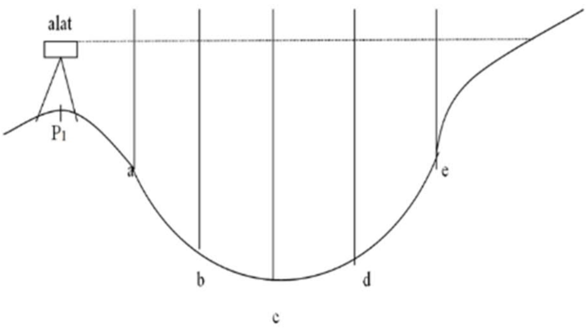
- The difference between the results of the back and front reading must be the same as the result of the difference in height (Δh), for an arithmetic check
- The accuracy is as follows:
  - The main route, which is generally a closed net, must be measured twice, namely going and returning. The difference between the two values for each section must be less than 7 √ k mm, where k is the distance in km between the benchmarks.
  - The Branch route are generally tied to the main network points for detail point control are sufficient once with an accuracy of 20 √k mm, where k is the distance in km.

6. Cross Section Survey

The measurement of the canal alignment plan is following the following requirement:

- Determining the ground elevation for the canal by the cross section and longitudinal survey method.
- All distances are measured directly in the field using a total station.
- Interval Cross Section is 50 m
- The location of the cross-sections will be determined using wooden stakes as described above. All pegs have measured by using Total Station and Automatic Levelling.
- Traverse must be closed to the nearest predetermined point (benchmark or azimuth marker) to check accuracy
- Cross Section measurement up to the irrigation area height (around 25 m)
- All features such as houses, facilities, roads, bridges, culverts, fences, concrete posts and vegetation (type and density) will be recorded.
- Special materials found on the ground, such as rocks, swamps, landslides and so on should be recorded.
- The cross-sectional heights will be recorded in the total station software.

Figure 2-44 Cross Section Method



<u>Accuracy</u>:

- All detailed elevation calculations must be completed and checked for accuracy before leaving the field.
- The relative height of the detailing point must meet an accuracy of 5 cm.
- The price of the height of the detailing point is calculated up to the nearest centimetre, the position of the points is marked with a decimal comma (dot) from the price of the height or a comma separated by using arrows if the details become blurred due to the previous location numbers.
- All detail points are clearly numbered so that inspections carried out through observation sheets at the next stage will be easier.

7. Drawings

Figure 2-45 Drawing example (1)

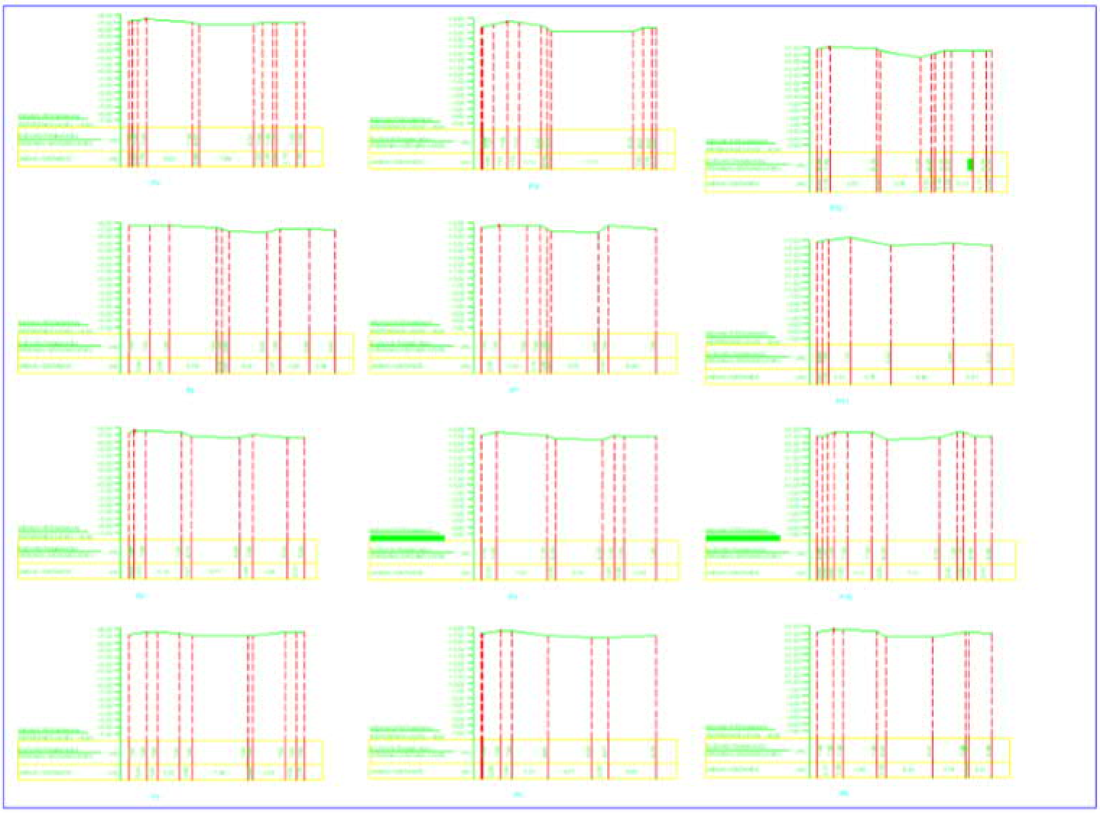
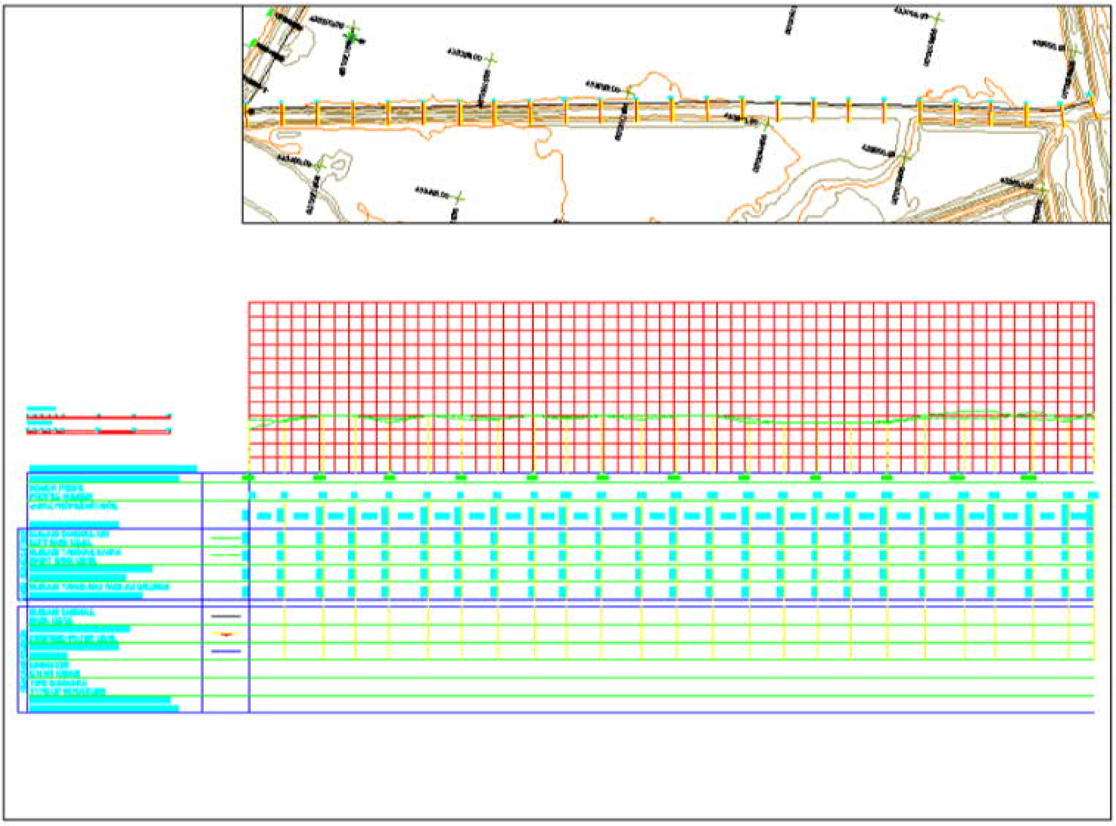


Figure 2-46 Drawing example (2)



8. Work Volume

Figure 2-47 Work volume according to the canal survey

NO.	LOKASI	JENIS SALURAN	PANJANG (M)
1	Kuprik Sidomulyo	Saluran Primer	4.376
2	Kurik	Saluran Primer	30.264
3	Jagebob	Saluran Primer	24.212
4	Salor	Saluran Primer	63.407
5	Tanah Miring	Saluran Primer	34.355
6	Semaryam	Oxbow	12.986
7	Jagebob	Saluran Sekunder	32.590
8	Jagebob	Saluran Tersier	4.538
TOTAL			206.728,707

3 Irrigation water and canals flows

3.1 General

Crop water requirement calculations are carried out during the planning stage of the scheme development, during the design and also during the operation period. For the planning exercise it will assist in determining the future cropping pattern, provide a water allocation and cropping intensity; and therefore, the development benefits. For the design stage, the peak crop water requirements determine the design capacity of the canals /system, and therefore, the size of the canals. For operation stage, the water requirements will be useful for water allocation and scheduling, and for the evaluation of the agricultural development plan.

Basically, the purpose of the calculation and analysis is to optimize the resource available to obtain the optimal results for the scheme. By adopting the suitable cropping pattern, water available will be used efficiently within the constraints of farmer choice. What is meant by the water available is the presence of water in the river, in the canals, and in the drainage canals that have a double function as a conservation storage. The reliable flows from the river are taken as those that are exceeded 80% of the time. The presence of water in the conservation /drainage canals is harder to determine as it is a combination of seepage, partly from irrigation and partly from drain water. However, it will most effectively be used should reliably flows from the rivers drop below 80% reliable levels.

When conservation canals/drains are connected with the supply primary canals, they can be considered as conservation canals. They will be available to provide water during the dry season cropping calendar if outlet structures are Stop logged. Farmers are then able to raise the water by pumping to their land.

The calculation of crop water requirements is subject to the agronomic needs, and may change as different crop varieties are introduced. Because of that reason, the calculation should be based on the easily adapted methodology for future scheduling activities. The calculation in this report is based on the standard given in the KP irrigation standards.

3.2 Basic agron omy

3.2.1 Irrigable area

In effort to maximize the contribution of agricultural sector in the economy of Merauke, the concept of a central area for agricultural commodities production has been developed. The concept is based on the suitability of the ecosystem, along with social, economic, and local cultural considerations.

Table 3-1 Types of food crop farming in Merauke, 2020

No.	Crop	Planted area (ha)	Production (ton)	Productivity (ton/ha)	Development area
1	Paddy	61,817	344,192	5.6	Tanah miring, Malind, Semangga, Kurik
2	Maize	447	1,382	3.1	Jagebob, Semangga, Tanah miring, Kurik
3	Soybean	28	54	1.9	Jagebob, Semangga, Tanah miring, Kurik
4	Mung beans	37	47	1.3	Jagebob, Semangga, Kurik, Ulilin
5	Groundnuts	313	699	2.2	Jagebob, Tanah Miring, Malind, Ulilin
6	Taro	357	3,803	10.7	Tanah Miring, Tabonji, Elikobel, Jagebob, Ulilin
7	Sweet potatoes	523	6,215	11.9	Tanah Miring, Jagebob, Waan, Merauke
8	Cassava	469	8,370	17.9	Jagebob, Tanah Miring, Kimaan, Waan, Tabonji

Source: Food crops, Horticulture and Plantation Service of Merauke District, 2021

Rice cultivation of indigenous people (Marind Tribe)

Since 1914, during the government of "Nederlands Nieuw Guinea" in Papua, Javanese people have been brought to Merauke as farmers who commonly cultivate lowland rice. At that time, the indigenous Papuans were first introduced to the commodity of lowland rice. In 1985, several indigenous Papuans tried to cultivate rice paddy fields but failed and stopped. Since 2007, the indigenous Papuans became interested again in cultivating lowland rice once they saw the success of the transmigrant farmers.

The indigenous Papuans are aware of the various kinds of fertilizers required for rice production, such as urea, NPK or other agricultural inputs, but do not know how to determine the dose and proper timing of fertilization, as well as the use of tractors for ploughing. Indigenous Papuans are generally aware of factual knowledge, namely knowledge of terminology, elements or concept, but on the other hand, procedural knowledge of how to apply or practice concepts in a real-life situation is, as yet, less understood. The indigenous Papuans’ interest in learning to cultivate paddy rice is not followed by a strong social or marketing network. This is marked by the absence of a spirit of togetherness, a sense of solidarity, cooperation, and exchange of information, so that the transfer of information on rice cultivation is hampered. The lack of information transfer on lowland rice cultivation from the facilitator to the indigenous Papuans leads to the latter still having a poor understanding of rice cultivation.

At present, indigenous Papuans have established social relations with various facilitators as a source to find the information of lowland rice cultivation both within and outside the tribal community.

Rice cultivation of migrants farmers

In general, the farming system is relatively modern, as agricultural machinery is already used in several activities such as tractors used for land preparation and combine harvester and threshing machines for harvesting. However, most farmers do not use fertilizer as is recommended, both in type and amount. Farmers in general already use superior seeds. The dominant varieties planted are Ciherang in the rainy season and Inpari 13 and Memberano for the dry season.

The main considerations in the choice of varieties are fluffier taste, early maturity, and currently considered the most resistant to disease attack (tungro). The farming management system is considered sub-optimal, especially during maintenance, and there is still the potential to increase productivity.

The farming system of the Javanese transmigration community which has a parent culture of rice farmers has become "a learning by doing process" for indigenous Papuans who previously subsisted by means of hunting and gathering although the women usually tended gardens with root crops such as sweet potatoes, cassava and yams.

Rice farming is generally carried out by transmigrant communities, who already started adopting farm mechanisation. Superior varieties and inorganic fertilizers have been applied, but crop productivity still needs to improve. Several factors contributing to the productivity of rice still needs to improve, especially those with a high iron (Fe) content. Such soils require heavy fertilization, especially Phosphate (P_2O_5), while the availability of fertilizer in areas is no guarantee that it will be sufficient amounts and arrive on time. In Merauke, the decline in rice quality is also caused by high rainfall at harvest time so that the drying process for grain is disrupted. Over time, the level of grain damage will increase.

The identified irrigable area for each scheme takes into account of land suitability and salinity in the river near the scheme intake and is presented in the **Table 3-2.**

Table 3-2 Potential lowland irrigation area

Irrigation schemes		Net area (ha)	River	Distance of intake from the sea	Expected period of saline water	Proposed cropping patterns
Central govt. schemes						
1	Kurik 2	2,059	Kumbe	81.6 km	None	Rr–Ri–Pi
2	Kurik 5 and 6	2,820	Kumbe	81.6 km	None	Rr–Ri–Pi

Irrigation schemes		Net area (ha)	River	Distance of intake from the sea	Expected period of saline water	Proposed cropping patterns
3	Kurik 1	2,311	Kumbe	81.6 km	None	Rr–Ri–Pi
4	Tanah Miring 9	1,890	Kumbe	52.8 km	Aug-Nov	Rr–Ri/Pi–F
5	Tanah Miring 4,7	1,294	Maro	55.8 km	Aug-Nov	Rr–Ri/Pi–F
6	Tanah Miring 2	1,001	Maro	38.7 km	Jun-Nov	Rr–F–F
7	Lower Jagebob	4,580	Maro	148.5 km	None	Rr–Pi–Pi
	Subtotal	**15,955**				
Province/District schemes						
8	Kuprik-Sidomulyo	1,944	Maro	23.2 km	Jan-Dec	Rr–F–F
9	Salor 1	1,411	Kumbe	60.8 km	Sep-Nov	Rr–Ri–F
10	Salor 2,3,4	3,135	Kumbe	81.6 km	None	Rr–Ri/Pi–Pi
11	Kumbe Kampung	477	Kumbe	81.6 km	None	Rr–Ri–Pi
	Subtotal	**6,967**				
New schemes						
12	Sermayam New	1,339	Maro	66.8 km	Sep-Nov	Rr–Pi–F
13	Salor Kampung	621	Kumbe	81.6 km	None	Rr–Pi–Pi
14	PMI Kumbe home yards	167	Kumbe	Variable	depends on location	vegetables & horticulture
15	PMI Maro home yards	73	Maro	Variable		
	Subtotal	**2,200**				
	Total phase-1	**25,122**				

Notes: Rr = Rice, rainfed Pi = Palawija, irrigated
Ri = Rice, irrigated F = fallow

3.2.2 Crops grown

Only two scheduled crops in general will considered in the calculations of water requirements. However, in practice farmers are free to grow the crops of their choice and timing.

Rice: Normally farmers in lowland areas grow paddy rice in standing water conditions. In the higher areas, such as Salor 2 and 4, some farmers to grow upland paddy in the wet season. The kind of rice will dictate the crop factors and infiltration rates.

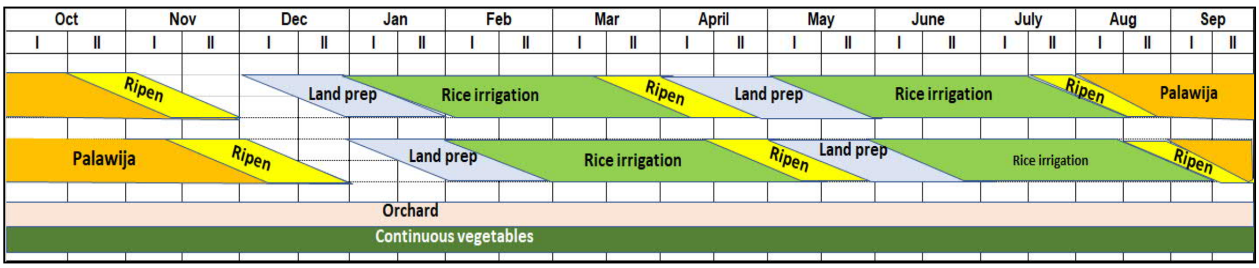
Palawija: Generally, in the form of cassava, ground nuts, maize and mung beans. Grown on ridges or within the field. When it is grown in the field, it has its own crop factor.

3.2.3 Planned cropping patterns in the area

The existing cropping patterns in the field are Paddy-Paddy-*Palawija*, although few famers grow the *palawija* crop at present. The first crop of rice cultivation usually starts at the beginning of December but could be earlier or later depending on rainfall. The second rice crop usually starts in April with irrigation completed by mid-September. The community is not familiar with the group (*golongan*) system, so they only rely on one group which is spread over two months as water becomes available.

The proposed cropping pattern is shown on Figure 3-1 with half of the rice farmers carrying out pre-saturation at the beginning of December and the other half pre-saturating through January, which is the same as a single group carrying out pre-saturation spread over 60 days.

Figure 3-1 Cropping pattern used for calculations.



After pre-saturation the rice fields are ploughed and harrowed whilst the rice is in a nursery and transplanted after 30 days. Irrigation of the crop follows for 75 days, then a half month for ripening when fields are drained down and no irrigation applied, and harvest takes place at the end of this period.

It is noted that each rice crop takes 120 days which is 15 days longer than the majority of rice crops grown. However, in areas where deeper inundation from flooding is likely, a minority of farmers will grow a taller variety that needs the extra time. The 120 days will therefore allow these farmers to stay synchronized with their neighbours who would probably take a 15-day break between harvest and pre-saturation for drying and marketing their grain.

To modernize and diversify the system it is also proposed to introduce pipe irrigation into the orchard (*pekarangan*) areas around the houses for high value fruit and vegetable crops. In the longer term, higher areas in Salor and Jagebob that require considerable pumping of irrigation water as well as proposed new schemes designated as *Usaha 2* may also convert to these crops and types of irrigation.

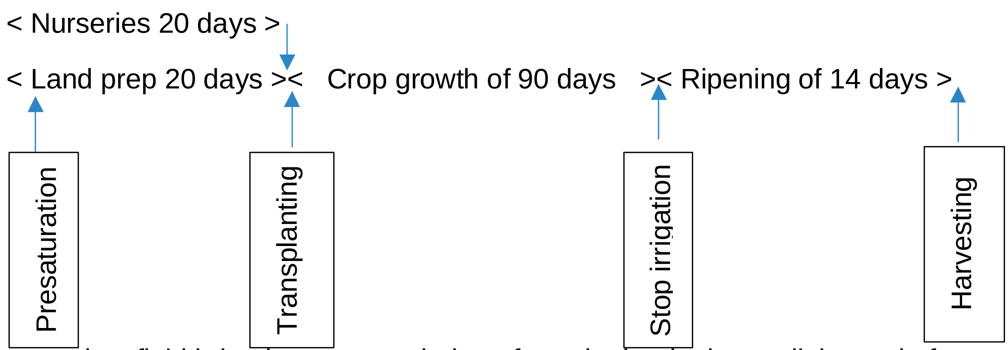
3.2.4 Types of rice planted

A seed multiplication centre exists in Kurik sub-district. The varieties that are widely used including *Memberamo*, *Ciherang* and *Inpari*. The selection of the rice variety by farmers is commonly based on its high productivity, the good rice taste and resistance to various pest and disease attacks. Rice cultivation technology has begun to be practiced by farmers using quality seeds prepared by local seed breeders. The selection of these varieties was based on its high productivity and resistance to various diseases such as tungro and false white pests. The range productivity of rice is between 4.10-5.15 ton/ha (Food crops, horticulture and plantation services of Merauke District, 2019).

3.2.5 Inundated rice

In the irrigation water calculations, inundated rice would be the main crop with the intensity of cropping depends on the water availability. Rice crop variety used in the calculation is IR 36 or IR 38. IR 36 is a high yield variety (HYV) with the total growth of 105 – 115 days. IR 38 also a high yield variety (HYV) with the total growth of 120 – 130 days.

In the calculation it is estimated in general that the land preparation is about 20 days, followed by the crop growth 90 days, and ripening of 14 days. Nurseries are established at the same time with land preparation.



In practice, field irrigations are carried out from the beginning until the end of crop growth.

3.2.6 Nurseries

Land Preparation

Land preparation can be done using a tractor. Rotary tractors and *singkal* are used on potential land, while on acid sulphate fields it is carried out with a sharp rotary blade, and without *Singkal* so as not to lift the Fe or pyrite layer from the soil. The depth of if not more than 20 cm or the ideal depth of 12-15 cm. Then level with a rake. The land is then pre-saturated for approximately one week with a water depth of 10-20 cm.

Herbicides need to be applied to ensure the cleanliness of the land. In the direct seed planting system (*Tanam Benih Langsung* - TABELA), herbicide application is carried out at pre-planting, pre-growing and post-growing, while in the transplanting system (*Tanam Pindah* - TAPIN), herbicide application is carried out at pre-planting and post-growing only.

Planting

Existing: with the scattering TABELA method

There are 2 methods

- Rice seeds are sown in dry conditions without seeds before germination
- Rice seeds are sown before being spread in the field. The pre-germination method is to soak the rice seeds for 2 days, then ripen for 2 days.

So that rice seeds can be sown evenly on the land, it is necessary to remove standing water on the land by making small drainage channels in the paddy fields. The average seed required for land with TABELA scatter is about 40-60 kg/ha.

Fertilization

Fertilizing timing:

Give all NPK at 0-10 DAP, 50% urea fertilizer at 24-27 DAP, and the rest is applied at 43-47 DAP (Balitra, 2015). The dose of NPK 15-15-15 fertilizer in a blanket (recommended package) is a total of 200 kg/ha of NPK and 125 kg/ha of Urea.

Table 3-3 Fertilizer recommendation for lowland rice in the Feasibility Study area

Sub-district	Single fertilizer (kg)				Compound fertilizer (kg)		
	Urea	ZA	SP-36	KCL	NPK 15-15-15/15-10-12	Urea	ZA
Tanah Miring	150	100	100	100	350	50	100
Semangga	150	100	100	100	350	50	100
Kurik	150	100	100	100	350	50	100
Jagebob	150	100	100	100	350	50	100
Malind	150	100	100	100	350	50	100

Source: Agricultural Research and Development Agency, Ministry of Agriculture.2020

3.2.7 Crop factors

Crop coefficients can then be adjusted for ½ monthly periods.as shown in **Table 3-4** below.

Table 3-4 Calculation of crop growth factors over time periods

Crops	Rice Crop Coefficients	Rice Time Period Coefficients			
Crop periods	HYV Crop values from Cropwat	Time period	H.Y.V Crop values from Cropwat	Palawija crop	Fruit + veg continuous
LP	LP	TP1	LP		
LP	LP	TP2	LP		
Maintenance	1.20	TP3	1.20		
CP1	1.20	TP4	1.16	0.7	0.91
CP2	1.03	TP5	1.06	0.75	0.91
CP3	0.97	TP6	0.97	0.88	0.91

Crops	Rice Crop Coefficients	Rice Time Period Coefficients			
Crop periods	HYV Crop values from Cropwat	Time period	H.Y.V Crop values from Cropwat	Palawija crop	Fruit + veg continuous
CP4	0.90	TP7	0.69	0.91	0.91
CP5	0.00	TP8	0.23	0.91	0.91
CP6		TP9	0.00	0.82	0.91
				0.41	0.91

Note: This table is for 30-day pre-saturation with growth periods following.

3.2.8 Cultivation Activities

Proposed Farming Practices of Paddy

The present farming practice of paddy under pump irrigation and rainfed condition in the Project area is proposed to adopt for the irrigation development because the present average yield of paddy is still room to be increased in productivity. The inputs and labour requirements for the paddy cultivation under gravity and pump irrigation conditions are shown in the following **Table 3-5.**

Table 3-5 Proposed Farm Inputs of Paddy per-hectare

Inputs	Unit	Irrigated (MT-1 and 2)	
		Gravity	Pump
1. Seed	kg	25	25
2, Fertilizer Urea	kg	150	150
NPK	kg	100	100
SP-36	kg	100	100
Organic	kg	0	0
3. Agrochemicals Insecticide	ltr	2	2
Pesticide	ltr	1.5	1.5
Rodenticide	ltr	0	0
Herbicide	ltr	0.25	0.25
4. Labour Nursery	man-day	3	3
Land Preparation	man-day	4	4
Transplanting	man-day	11	11
Weeding	man-day	10	10
Fertilizer application	man-day	3	3
Agrochemical application	man-day	3	3
Water management	man-day	8	8
Harvesting and drying	man-day	5	5
5. Pumping of irrigation	ltr	0	48

Source: Study team

The current rice yield, under irrigated conditions, is estimated as in the **Table 3-6** below.

Table 3-6 Estimated Yield of Paddy per hectare

Item	Unit	MT-1	Mt-2	MT-3
Irrigated (Gravity & Pump)	ton	5,535	6,103	-

Source: Study Team

The anticipated production of paddy in the Project area are estimated in accordance with the proposed harvesting area and anticipated yield. Anticipated production of paddy by area and season are shown in the **Table 3-7** below.

Table 3-7 Estimated Paddy Production (unit: ton)

Item	Phase - 1			Phase - 2		
	MT-1	MT-2	MT-3	MT-1	MT-2	MT-3
Irrigated (Gravity)	95,441	-	-	87,580	-	-
Irrigated (Pump)	40,903	95,106	-	37,534	105,074	-
Total	136,345	95,196	-	125,114	105,074	-

Source: Study Team

Proposed Farming Practices of Palawija (Maize)

For the same reason as paddy mentioned above, the present farm inputs and the labour requirement for maize under pump or gravity irrigation and condition are adopted in the Project area as follows:

Table 3-8 Proposed Farm Inputs of Palawija per-hectare (Maize)

Inputs	Unit	Irrigated (MT- 2 &3)	
		Gravity	Pump
1. Seed	kg	20	20
2, Fertilizer Urea	kg	150	150
NPK	kg	75	75
SP-36	kg	-	-
Organic	kg	150	150
3. Agrochemicals Insecticide	ltr	1.5	1.5
Pesticide	ltr	-	-
Rodenticide	ltr	-	-
Herbicide	ltr	-	-
4. Labour Land Preparation	man-day	7	7
Transplanting	man-day	6	6
Weeding	man-day	5	5
Fertilizer application	man-day	3	3
Agrochemical application	man-day	3	3
Water management	man-day	9	9
Harvesting and drying	man-day	10	10
5. Pumping of irrigation	ltr	0	24

Source: Study team

The present yield of maize under irrigated condition is also estimated as shown in **Table 3-9** below.

Table 3-9 Estimated Palawija Production (unit: ton)

Item	Phase - 1			Phase - 2		
	MT-1	MT-2	MT-3	MT-1	MT-2	MT-3
Irrigated (Gravity)	-		-	-	-	-
Irrigated (Pump)	-	16,773	44,132	-	7,399	35,955
PMI	970	970	970	12,931	12.931	12,931
Total	970	17,743	45,102	12,931	20,330	48,886

Source: Study Team

Farm mechanization

The application of agricultural mechanization needs to be further introduced to increase efficiency especially for activities in the production process. The application of agricultural mechanization is expected to improve the degree and standard of the quantity and quality of rice, decrease the labour costs, shorten the planting time and encourage young people to become commercial and productive farmers as well as to reduce the problem of labour availability. Consequently, mechanization is urgently needed. Based on the statistical data of Central Bureau of Statistics, although the number of workers in the agricultural sector increased from 41,233 person in 2015 to 55,000 person in 2019, the use of agricultural machinery both for land preparation in the wet land and harvesting rice remains a main option for farmers because of it can reduce production costs compared to the use of human labour.

Agricultural equipment and tool assistance from the Government is given to farmer groups who are active and have been able to manage their groups and activities well. The data of agricultural tools and equipment is shown in **Table 3-10** below.

Table 3-10 Number of agricultural tools and equipment in the Master Plan area

Item	Type	Sub-District						
		Semangga	Tanah Miring	Kurik	Jagebob	Malind	Animha	Okaba
Tractor		609	931	571	66	315	no data	3
Thresher	(power)	465	774	411	0	214	no data	3
Water pumps (Size in inches)	2"	1	5	3	0	0	no data	1
	3"	934	1632	812	0	252	no data	1
	4"	1	5	3	0	0	no data	1
	6"	246	235	278	0	174	no data	0
	8"	126	8	18	0	8	no data	0
	others	0	3	2	0	0	no data	0
Transplanter		9	19	0	0	4	no data	0
Stripper		20	23	52	0	17	no data	0
Combine harvester		56	89	51	7	40	no data	3
Dryer	Bed	1	0	1	0	2	no data	0
	Vertical	0	0	0	0	0	no data	0
Rice milling machine	small	25	58	31	2	15	no data	1

Table above shows the number of equipment available in the Master Plan study area, which consists of machinery for land management, such as tractors, transplanters, water pumps, paddy threshers and rice harvesters.

However, its implementation in the field is still limited due to (1) the lack of knowledge of farmers in the maintenance and repair of agricultural equipment, and (2) the lack of skills and knowledge of farmers to manage the organization at farm level, and (3) lack of maintenance budget faced by Gapoktan raises a difficulty preparing the agricultural machinery feasible to use, as a lot of equipment cannot be used properly. In other words, good maintenance requires the discipline of the operator or mechanic, technical knowledge about these equipment, and simple repair tools and tools. This activity really requires the existence of a workshop that is equipped with adequate tools, a technician with good technical skills and knowledge, easily accessible by farmers, and having proper spare parts available.

Agricultural land in the Master Plan Study area consists largely of holdings with an area of more than two hectares. The dominant agriculture is rice cultivation. In the Master Plan study area, farmers generally use agricultural equipment for preparation of land by renting a tractor from a tractor owner at a cost of between Rp 1.5-1.8 million per hectare, until the land is ready for planting. Alternatively farmers can become a member of a farmer group (*Gapoktan*) that owns tractors where the user has to bear the cost of fuel and oil. The use of tractors is carried out with a system of taking turns between the other *Gapoktan* members. For rice planting activities, farmers commonly use human labour (family labour). Rice planting machines are used by seed breeders, in collaboration with Board of Seeds Centre (BBI-*Balai Benih Induk*) - Ministry of Agriculture, located in Kurik sub-district. By using a planting machine, it is possible to determine adequate spacing for the planted seeds and produce superior seeds because it is done with good cultivation. Another agricultural activity that requires rented agricultural equipment is harvesting using a combine harvester that is rented at a cost of around Rp 1.75 million per hectare, or under other conditions paying with the milled rice for about 250 kg (assuming 5 bags @ 50 kg/bag, at price about Rp 7,000/kg) per- hectare.

For other activities such as spraying for pests and diseases attack, each farmer commonly has their own sprayer and there is no need for renting the sprayer.

3.3 Soil conditions

From 1980's up to now there are several survey and studies on soils that have focussed on the information to support the analysis of soil suitability. For example, there was a study carried out by the IPB with the coverage of the lowland areas in Merauke that is close to coastal areas. Another study was carried out by the UGM to justify the suitability agriculture development. The soil survey and studies to support MIREE/MIFEE have not been collected . The missing data with the existing soil studies are about the infiltration rates.

3.3.1 Result of Land Suitability Analysis

The land suitability analysis is described in the Soil Assessment Report. It presents the potential land suitability in the master plan area, using technical guidelines for land evaluation from the BBSDLP and using qualitative soil characteristics base data from semi-detailed soil mapping on a scale of 1: 50,000 prepared by BBSDLP in 2016. Land suitability assessments were carried out for some agricultural commodities, which include the main food crops: 1. Irrigated wetland rice, 2. Rainfed lowland rice; secondary arable crops group: 3. Maize, 4. Soybeans, 5. Groundnuts, 6. Cassava, 7. Sweet potato; horticultural crops group: 8. Chili, 9. Onion; smallholder plantation group: 10. Rubber, 11. Sugarcane, 12. Coffee, 13. Cocoa; fruit plants group: 14. Orange, 15. Breadfruit; forage fodder 16. Elephant grass/Setaria grass; and 17. potential pasture area.

The land suitability analysis carried out is a single purposes analysis, where each commodity is analysed for its suitability in all landforms found in the master plan study area. All landform is assumed to be in a natural condition, not cultivated yet. In summary, each land suitability class size for all the analysed commodities is presented in **Table 3-11.**

Table 3-11 Area of each land suitability class for some crops

No.	Commodity	Area of Suitability class (ha)			
		S2	S3	Total S	N
1	Irrigated wetland rice	103.436	611.154	714.590	8.888
2	Rainfed rice	283.436	431.154	714.590	8.888
3	Maize	180.000	403.213	583.213	140.265
4	Soybean	114.435	468.778	583.213	140.265
5	Groundnut	152.387	430.826	583.213	140.265
6	Sweet potato	152.387	430.826	583.213	140.265
7	Chilli	152.387	425.376	577.763	145.715
8	Onion	152.387	425.376	577.763	145.715
9	Sugar cane	180.000	403.213	583.213	140.265
10	Coffee	86.822	332.562	419.384	304.094
11	Rubber	114.435	468.778	583.213	140.265
12	Lemon	152.387	430.826	583.213	140.265
13	Mango	180.000	403.213	583.213	140.265
14	Breadfruit	180.000	403.213	583.213	140.265
15	Elephant grass	152.387	425.376	577.763	145.715
16	Pasture	-	723.478	723.478	-

Estimated land suitable for irrigated wetland rice reached 191,281.53 Ha or 95.04% of the total FS area with marginally suitable class (S3). Currently not suitable land (N1) is 6,029.21 Ha (3.00 %), and permanently not suitable (N2) is 3,022.40 Ha (1.50 %). The distribution area of land suitability for irrigated wetland rice is presented in **Table 3-12**, while its spatial distribution shown in **Figure 3-2**.

Figure 3-2 Land suitability map for irrigated wetland rice

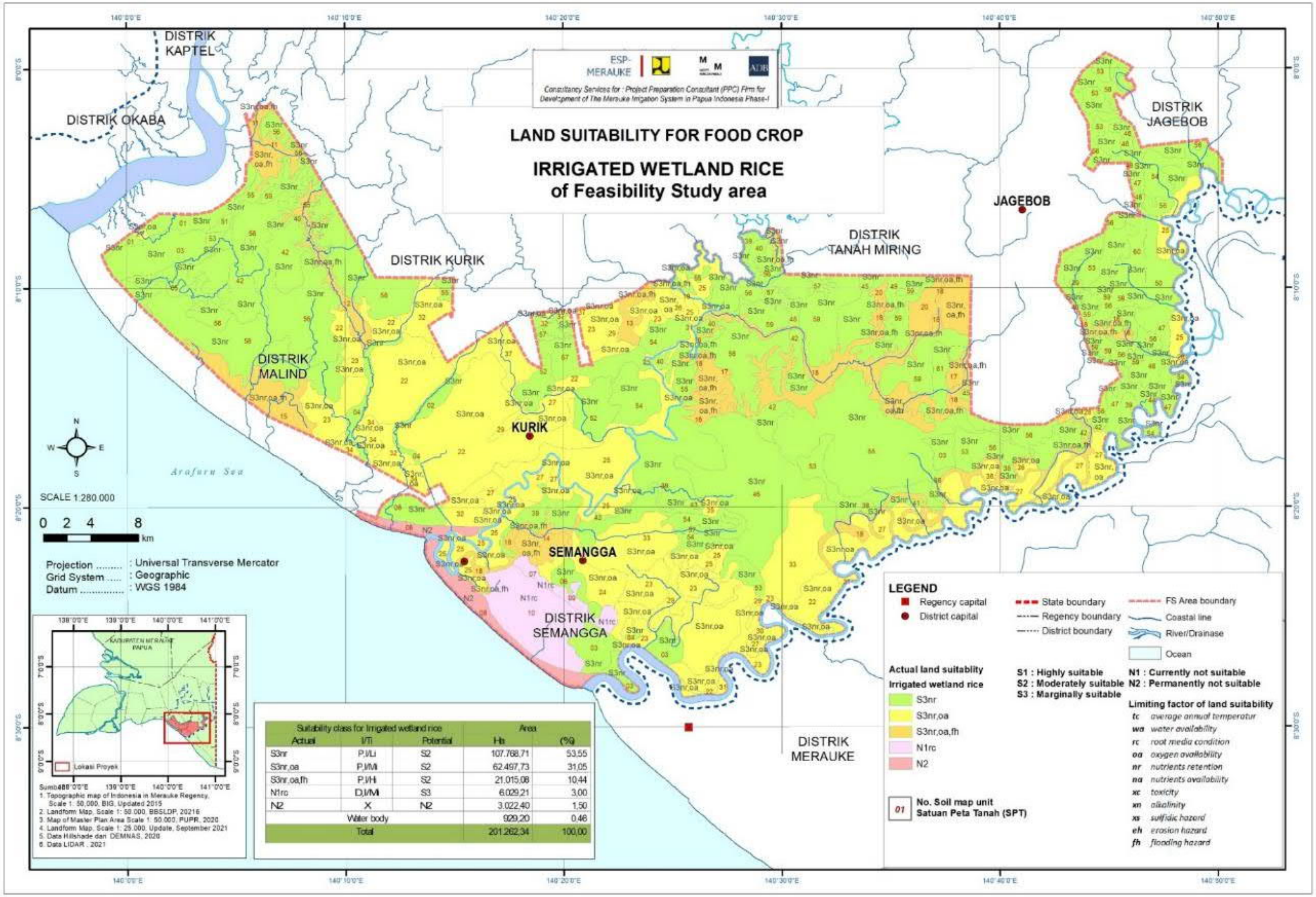


Table 3-12 The distribution area of land suitability for irrigated wetland rice

Suitability class for irrigated wetland rice			Area	
Actual	I/Ti	Potential	ha	(%)
S3nr	P,I/Li	S2	107.768,71	53,55
S3nr,oa	P,I/Mi	S2	62.497,73	31,05
S3nr,oa,fh	P,I/Hi	S2	21.015,08	10,44
N1rc	D,I/Mi	S3	6.029,21	3,00
N2	X	N2	3.022,40	1,50
Water body			929,20	0,46
		Total	**201.262,34**	**100,00**

Note (will be applied for other related tables):
Land suitability class: S2 = Moderately suitable, S3 = Marginally suitable,
N1 = Currently not suitable, N2 = Permanently not suitable

Limiting factor:
nr = nutrient retention
oa = oxygen availability
fh = flooding hazard
rc = root media condition

Input for land improvement :
D = drainage
P = chemical fertilizing

Improvement level
Li = low input
Mi = moderate input
Hi = high input

Land suitability class of marginally suitable (S3)

Marginaly suitable land (S3) is limited by the conditions of soil fertility (nr), oxygen availability of the drainage condition (oa), and flooding/inundation hazard (fh). Currently not suitable land since soil texture as root media become a limiting factor (rc) and permanently not suitable land (N2) with coarse soil texture as a limiting factor (rc).

According to the Land Suitability Assessment Criteria for Agricultural Commodities (Ritung et al., 2011), irrigated wetland rice requires moderate to moderate drainage, fine to moderately fine texture, soil depth > 50 cm, and moderate total N, high P2O5 and moderate K2O .

S3nr: limited by very low nutrient retention or soil fertility (nr) conditions. The suitability of the S3nr land includes Alluvial Gleic soils (SPT-1 to SPT-6), Regosol gleic (SPT-9 and SPT-10), Gleisol district (SPT-41 to SPT-48), Gleisol eutric (SPT-49 to SPT-48). SPT-51), Cambisol district (SPT-54 to SPT-62), Cambisol eutric (SPT-63 and SPT-64), Cambisol gleic (SPT-52), and Cambisol chromic (SPT-53).

To improve the limiting factor of very low soil fertility, it is necessary to apply NPK chemical fertilizer with a given dose to achieve low total N-nutrient availability, moderate P2O5, and low K2O, so that the potential land suitability class becomes Moderately suitable (S2), or with high doses to achieve moderate N-total nutrient availability, high P2O5, and moderate K2O, so that become a Highly suitable potential land suitability class (S1) can be achieved.

S3nr,oa: this land suitability class show the condition instead of the very low soil fertility as a limiting factor, the very poor drainage condition also become a limiting factor (OA). The suitability of the S3nr,oa soil includes Gleisol fluvik (SPT-24 to (SPT-34) and Gleisol humik (SPT-35 to SPT-40).

S3nr,oa,fh: this land suitability class, in addition to low to very low soil fertility (nr) and the very poorly drainage (oa), there is also a limiting factor of inundation/flooding hazard (fh) to this soil unit. The suitability class of the S3nr,oa,fh of the soil unit includes types of Gleisol hydric (SPT-14 to SPT-23).

To improve the limiting factor of very low soil fertility, it is necessary to apply NPK chemical fertilizer with a given dose to achieve low total N-nutrient availability, moderate P2O5, and low K2O, so that the potential land suitability class becomes moderately suitable (S2), or with high doses to achieve moderate

N-total nutrient availability, high P2O5, and moderate K2O, so the highly suitable potential land suitability class (S1) can be achieved.

Soil drainage conditions are the effect of the rate of percolation of water into the soil on air aeration in the soil. Drainage conditions are severely hampered (*very poorly drained*), indicating that the soil has very low hydraulic conductivity and very low water holding capacity, the soil is permanently wet and inundated for a long time to the surface. Such soil is suitable for irrigated paddy rice and a small number of other crops. The characteristic that can be seen in the field is that the soil has a permanent gley colour (reduction) to the surface layer. Irrigated wetland rice plants require slightly hampered to moderately good (moderate) drainage. In order for the drainage conditions to be somewhat poorly to somewhat good (moderate), it is necessary to improve the soil drainage system by making small drainage channels. Meanwhile, for land map units that have inundation/flooding hazards, it is necessary to improve the soil drainage system by making larger canals or drains so that they can discharge stagnant water into the main channel or into the river.

Efforts to make improvements to the drainage system can improve land suitability which was originally marginal (S3) to be moderately suitable (S2).

Land suitability class of currently not suitable (N1)

N1-rc: the limiting factor is the coarse soil texture class (sandy loam) and excessively drainage, which includes Regosol gleicsoils (SPT-7) and Regosols eutric (SPT-12 and SPT-13).

Excessively drained conditions indicate that the soil has high to very high hydraulic conductivity and low water holding capacity. Such soils are not suitable for crops without irrigation. Irrigated wetland rice plants require slightly poorly to moderately good (moderate) drainage. In order for drainage conditions to be somewhat poorly to somewhat good (moderate), it is necessary to improve the soil drainage system by making rice embankments, silting by ploughing the soil to reduce the speed of percolation of water into the soil, as well as providing organic matter which is also expected to improve soil texture. On existing lands, organic matter can be added by returning the remaining harvested rice straw to the soil.

Efforts to make improvements to the drainage system can improve land suitability class which was originally currently not suitable (N1) to become marginally suitable (S3).

Land suitability of permanent non-suitability (N2)

N2-rc: the dominant limiting factor is the very coarse soil texture class (sand), which includes Regosol gleic soils (SPT-8 and SPT-11).

This N2-rc is a permanently not suitable land suitability class, the soil unit cannot be improved.

3.3.2 Infiltration rate

The rate of percolation is very dependent on the properties of the soil. In heavy clay soils with good puddling characteristics, the percolation rate can reach 1-3 mm/day. There are no soil infiltration rates available. Some assumptions have been made for the study area is 3 mm/day.

3.3.3 Pre-saturation requirements

The pre-saturation value is presented in **Table 3-13** and the detailed calculations are in Appendix A.

Table 3-13 Field pre-saturation requirements

Month	Days	Basic Data								
		ETo	P	Reff	Eo = ETo * 1.1	M = Eo + P	T	S	K = M * T / S	LP = M * ek / (ek -1)
		1	2	3	4	5	6	7	8	9
		(mm/day)	(mm/day)	(mm/day)	(mm/day)	(mm/day)	day	mm		(mm/day)
Jan	15	3.78	3.00	1.96	4.16	7.16	60	300	1.43	9.41
	16	3.68	3.00	4.07	4.05	7.05	60	300	1.41	9.33

Month	Days	Basic Data								
		ETo	P	Reff	Eo = ETo * 1.1	M = Eo + P	T	S	K = M * T / S	LP = M * ek / (ek -1)
		1	2	3	4	5	6	7	8	9
		(mm/day)	(mm/day)	(mm/day)	(mm/day)	(mm/day)	day	mm		(mm/day)
Feb	14	3.57	3.00	3.08	3.93	6.93	60	300	1.39	9.24
	14	3.47	3.00	3.75	3.82	6.82	60	300	1.36	9.16
Mar	15	3.38	3.00	4.90	3.72	6.72	60	200	2.01	7.75
	16	3.28	3.00	2.82	3.61	6.61	60	200	1.98	7.66
Apr	15	3.26	3.00	2.39	3.59	6.59	60	200	1.98	7.65
	15	3.25	3.00	1.22	3.58	6.58	60	200	1.97	7.64
May	15	3.25	3.00	0.42	3.58	6.58	60	200	1.97	7.64
	16	3.24	3.00	0.25	3.56	6.56	60	200	1.97	7.63
Jun	15	3.23	3.00	0.06	3.56	6.56	60	200	1.97	7.62
	15	3.23	3.00	0.20	3.55	6.55	60	200	1.97	7.62
Jul	15	3.25	3.00	0.09	3.57	6.57	60	200	1.97	7.64
	16	3.39	3.00	0.03	3.73	6.73	60	200	2.02	7.76
Aug	15	3.73	3.00	-	4.10	7.10	60	200	2.13	8.06
	16	4.13	3.00	-	4.54	7.54	60	200	2.26	8.42
Sep	15	4.58	3.00	-	5.03	8.03	60	200	2.41	8.83
	15	4.83	3.00	-	5.31	8.31	60	200	2.49	9.06
Oct	15	4.96	3.00	-	5.46	8.46	60	200	2.54	9.19
	16	5.03	3.00	-	5.53	8.53	60	200	2.56	9.25
Nov	15	4.99	3.00	-	5.49	8.49	60	200	2.55	9.21
	15	4.80	3.00	-	5.27	8.27	60	200	2.48	9.03
Des	15	4.41	3.00	0.32	4.85	7.85	60	200	2.35	8.67
	16	4.12	3.00	1.24	4.53	7.53	60	200	2.26	8.41

3.4 Hydrology

3.4.1 General

Merauke District is included in the tropical climate category where the wet season lasts for 5 months from December to April while the dry season lasts for 7 months from May to November. Based on the BMKG Mopah station (Merauke) the annual average rainfall is 1,700 mm, but in general there is an increase in rainfall from South Merauke towards north Merauke where, the closer to the north, the rainfall is increasing.

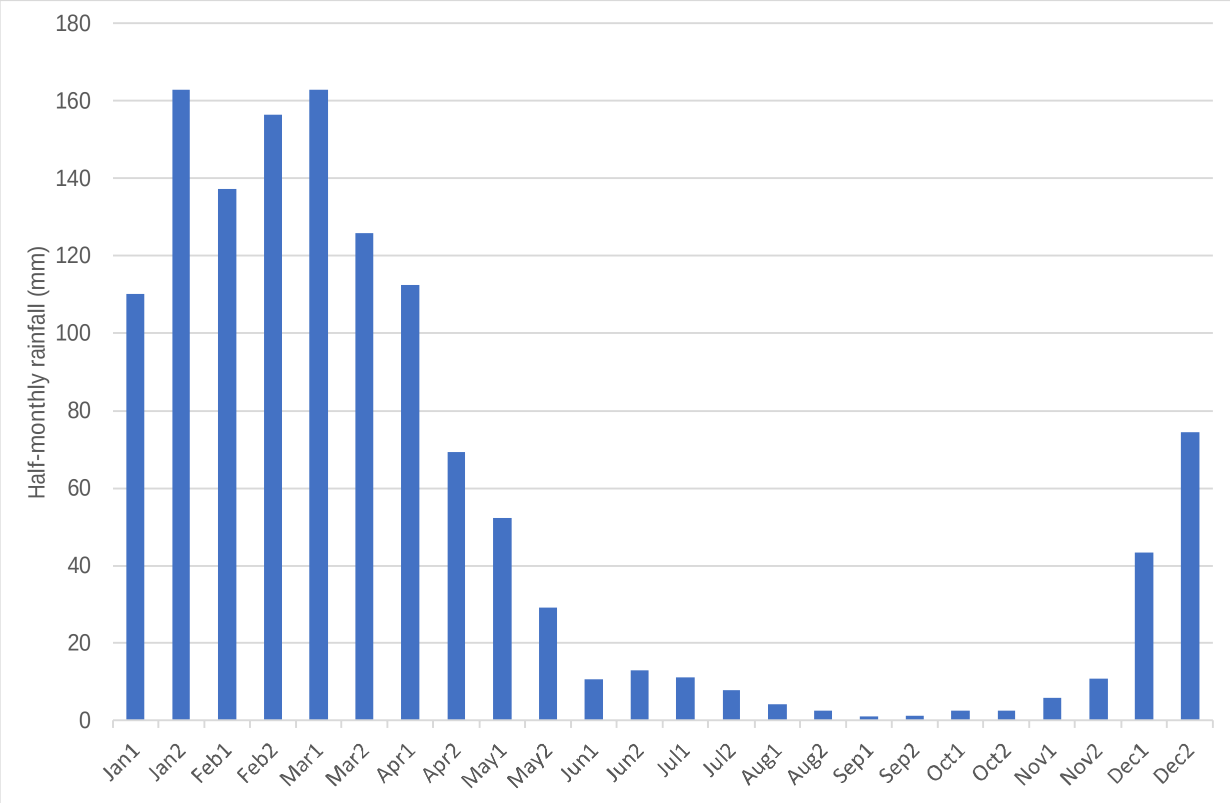
Based on climate data released by the Mopah BMKG from 1990-2019, it shows that wind speeds range from 2.3 to 3.8 m/s, where the highest wind speed is during the dry season in September at 3.8 m/s. The average of sunshine is around 5.4 hour, while the largest in October at 6.9 hours. The humidity level is quite high because it is influenced by the Wet Tropical climate, the average humidity is between 76 - 83.5%. The average temperature in Merauke District is 26.9 °C with the lowest temperature in August of 25 °C and the highest temperature in November is 28.3 °C.

3.4.2 Median rainfall and effective rainfall

The most extensive data available in the study area is for Mopah (Merauke), but this is at the coast and conditions may be significantly different at inland locations, particularly in terms of rainfall. Historic records have therefore been reviewed, particularly from the 1986 Transmigration planning reports[3].

The recent rainfall data that comes from BMKG Mopah Station covers from 1990 to 2019, though 1996 appears to be missing. Most of the period has daily data, but for a limited period only monthly totals were available. Half-monthly rainfalls are tabulated in the Hydrology Report. There is a very clear seasonal pattern, as illustrated in **Figure 3-3** which shows the median half-monthly rainfall. The median is shown rather than the mean because it is considered to give a more representative impression; in the dry season the mean can be much higher than the median as a result of a small number of high values.

Figure 3-3 Median half-monthly rainfall at Mopah, Merauke (1990-2019)



In median conditions there is very little rainfall from June to November inclusive. The wet season (December to May) has around 80% of the annual rainfall using the median calculations, and even more (85%) using mean rainfall.

Calculations of irrigation requirements incorporate an allowance for effective rainfall. The standard approach for this in Indonesia is to adopt 70% of the 1-in-5 year (i.e. 80% reliable) half-monthly rainfall. The proposed irrigation areas are quite close to the coast, so the Mopah rainfall data is appropriate. The effective rainfall values are shown in **Table 3-14.**

Figure 3-4 illustrates the profile and compares it to the median rainfall; whereas median rainfall starts to rise in November (and does so strongly from December), the pick-up in effective rainfall is later and more gradual.

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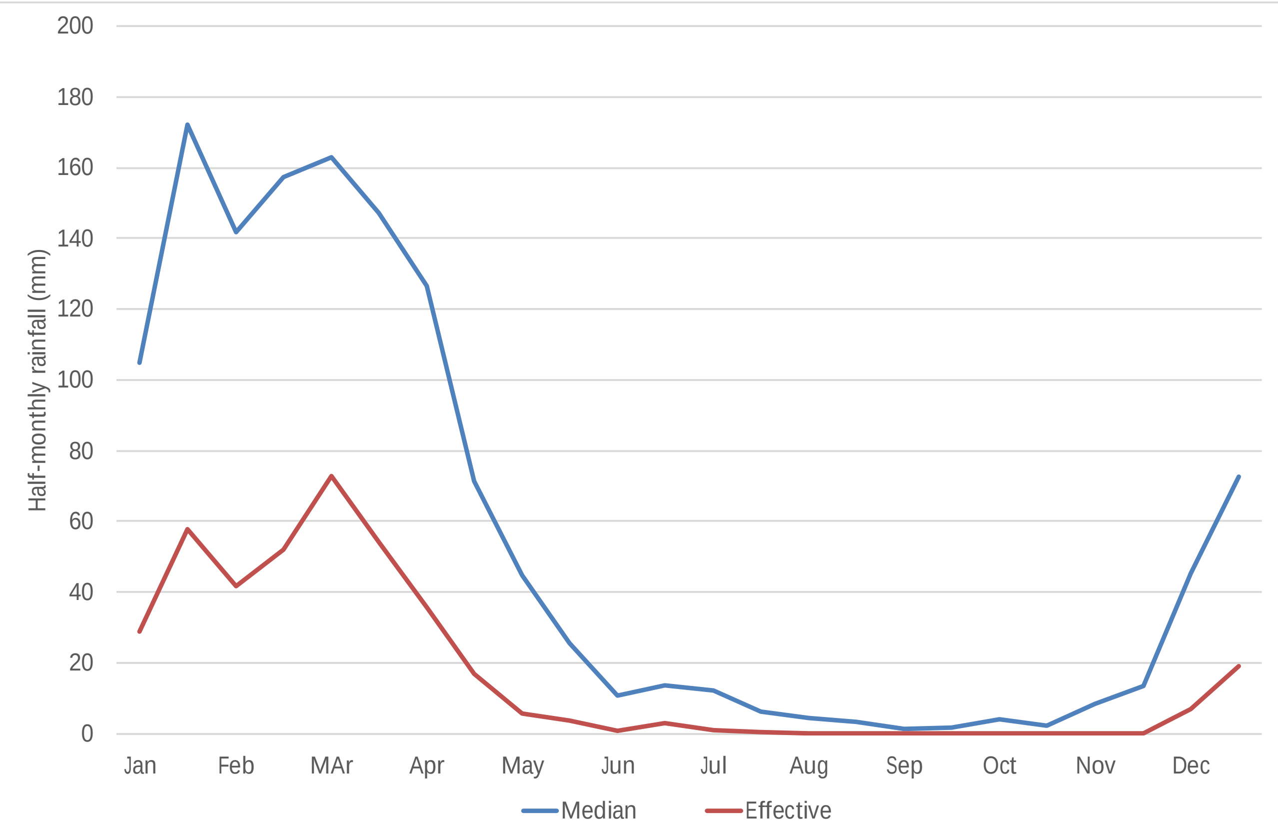
[3] Regional Physical Planning Programme for Transmigration (RePPProT), Review of Phase 1 results Irian Jaya, ODA (UK) and Departemen Transmigrasi (Indonesia), December 1986

Table 3-14 Half-monthly effective rainfall

Half month	(mm)	(mm/day)	Half month	(mm)	(mm/day)
Jan 1	29	1.9	Jul 1	1	0.1
Jan 2	58	3.6	Jul 2	0	0.0
Feb 1	42	3.0	Aug 1	0	0.0
Feb 2	52	3.7	Aug 2	0	0.0
Mar 1	73	4.9	Sep 1	0	0.0
Mar 2	54	3.4	Sep 2	0	0.0
Apr 1	36	2.4	Oct 1	0	0.0
Apr 2	17	1.1	Oct 2	0	0.0
May 1	6	0.4	Nov 1	0	0.0
May 2	4	0.2	Nov 2	0	0.0
Jun 1	1	0.0	Dec 1	7	0.5
Jun 2	3	0.2	Dec 2	19	1.2

Figure 3-4 Comparison of median and effective rainfall



3.4.3 Climate data and evapotranspiration

Climate data is needed for estimating rates of potential evapotranspiration (PET). These are required for the rainfall-runoff model and for determining irrigation water requirements. PET can be estimated from four variables – temperature, humidity, wind speed and solar radiation. Radiation is usually estimated from sunshine data.

Climate data is generally much less readily available than rainfall data, primarily because of the equipment required. Maintenance can also be an issue and it is not unusual for records to be intermittent.

However, records for the Mopah meteorological station cover an extended period (1990-2019) and are reasonably complete – temperature and humidity for close to 90% of the time, though only around 65% for sunshine and wind speed. The half-monthly averages are shown in **Table 3-15**; these are derived from all half-months with data rather than restricted to the years with complete data. The full data is included in the Hydrology Report**.**

Table 3-15 Average climatic conditions - Mopah

	Average Temperature (°C)	Relative humidity (%)	Sunshine (hours)	Wind Speed (m/s)
Jan 1	27.9	80.8	5.0	2.5
Jan 2	27.5	82.1	4.8	2.5
Feb 1	27.6	82.8	5.2	2.8
Feb 2	27.4	83.2	5.3	2.6
Mar 1	27.4	83.5	4.8	2.7
Mar 2	27.5	83.2	4.9	2.4
Apr 1	27.4	82.8	5.1	2.3
Apr 2	27.3	82.2	5.2	2.5
May 1	27.1	82.6	5.4	2.6
May 2	26.7	82.2	5.4	2.7
Jun 1	26.2	81.7	4.8	2.9
Jun 2	25.7	82.4	4.2	3.0
Jul 1	25.4	81.6	4.4	3.0
Jul 2	25.1	81.1	4.7	3.2
Aug 1	25.0	79.4	5.1	3.4
Aug 2	25.3	79.0	5.7	3.4
Sep 1	25.7	77.7	5.8	3.7
Sep 2	26.3	77.8	6.1	3.8
Oct 1	26.9	77.0	6.6	3.4
Oct 2	27.5	76.3	6.9	3.3
Nov 1	27.8	76.7	6.2	3.2
Nov 2	28.3	76.8	6.4	3.0
Dec 1	28.3	78.7	5.7	2.7
Dec 2	27.9	79.3	5.4	2.7
Year	26.9	80.5	5.4	2.9

Estimates of reference crop evapotranspiration (i.e. PET) have been made through the widely-used Modified Penman method, calculations for which are shown in the Hydrology Report. The final of half-monthly evapotranspiration values is shown in **Figure 3-5 and Table 3-16**

Figure 3-5 Reference crop evapotranspiration

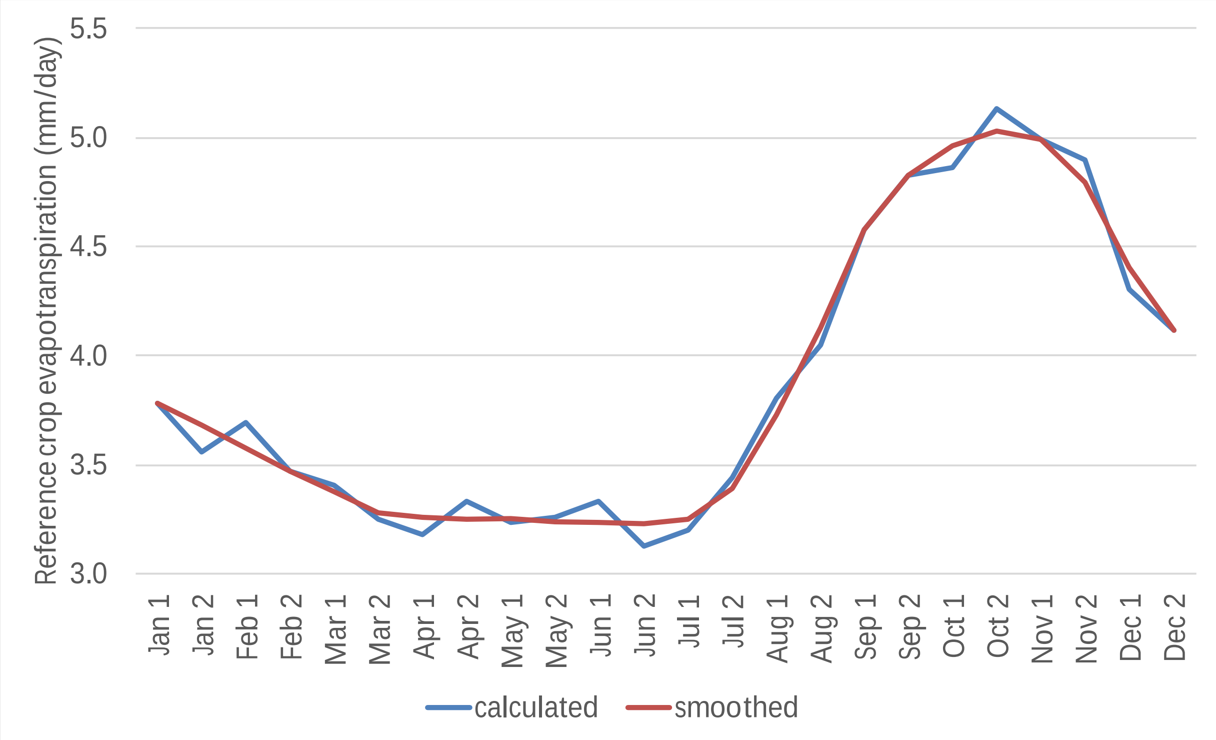


Table 3-16 Reference crop evapotranspiration - Mopah

Half month	mm/day	Half month	mm/day
Jan 1	3.78	Jul 1	3.25
Jan 2	3.68	Jul 2	3.39
Feb 1	3.57	Aug 1	3.73
Feb 2	3.47	Aug 2	4.13
Mar 1	3.38	Sep 1	4.58
Mar 2	3.28	Sep 2	4.83
Apr 1	3.26	Oct 1	4.96
Apr 2	3.25	Oct 2	5.03
May 1	3.25	Nov 1	4.99
May 2	3.24	Nov 2	4.80
Jun 1	3.23	Dec 1	4.41
Jun 2	3.23	Dec 2	4.12
Annual average			3.87

3.4.4 River water levels

During the hydrometric surveys at the end of December 2021, which is at the wet season, water level measurement and analysis have been carried out. The result is shown in **Figure 2-20** for Kumbe River, and **Figure 2-22** for Maro River.

It is estimated that during the dry seasons, the average water level at the river mouth will be remain at the same level. But, at the measurement point at the km 110 for Kumbe River, and km 140 for Maro River, will be about 1.5 m higher for Kumbe, and 2 m higher for Maro. The average level of Kumbe upstream varies from +2,50 m during the dry seasons to +4.00 m during the wet seasons. For Maro River, it varies from +2,0 m to +4.0 m.

3.4.5 Maro and Kumbe River discharges

Assessment of reliable flows for an irrigation system should be made using a reasonably long period of data that captures the range of conditions that are likely to occur in the catchment. Only relatively short periods of flow values are available, but there is more extensive rainfall data. If a model can be calibrated to the period of flow values, it can be used to create a longer flow series using the available rainfall data.

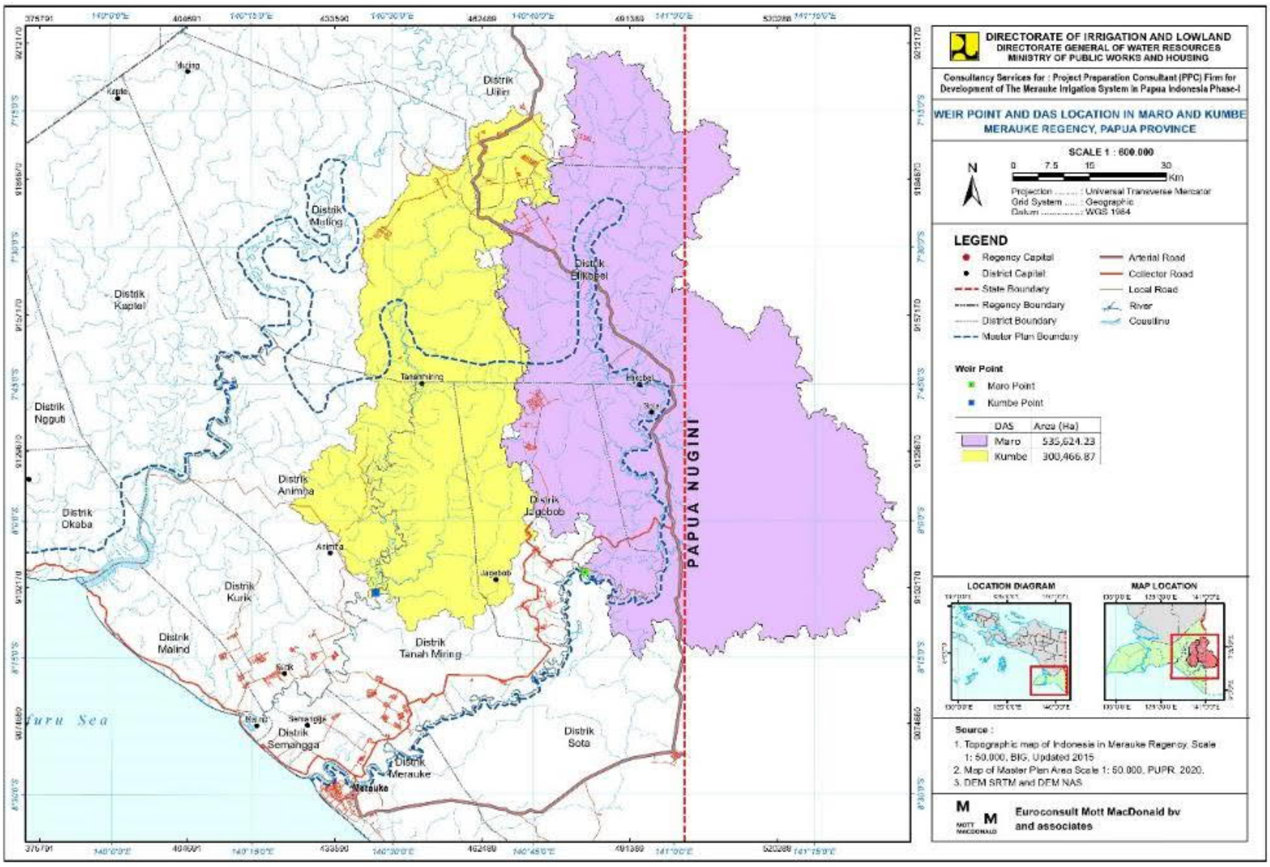
In Indonesia the Mock model is widely used where flow estimates are required for assessing irrigation schemes. The Mock method refers to the water balance, which consider the inflow, outflow, and storage of groundwater. It was developed on a monthly time step but can be applied half-monthly. The main model parameters are listed in **Table 3-17**. Although listed last the catchment area is probably the single most important parameter for any rainfall-runoff model, since without this the total runoff volume produced by the model is almost certainly wrong.

Table 3-17 Mock model parameters

Parameter	Units/comment
Soil moisture capacity	mm (depth)
Processed agricultural land percentage	Typically, 30-50% for paddy fields, would be 0% for dense forest
Infiltration coefficient	Between 0 and 1, very dependent on soils
Groundwater recession coefficient	Between 0 and 1, dependent on underlying geology
Fast runoff fraction	Typically very low, but would reflect urban hard surface areas or open water
Rainfall factor	Typically 1, but may be changed if it is thought that the rainfall data under- or overstates the catchment rainfall.
Catchment area	km^2

Although listed last the catchment area is probably the single most important parameter for any rainfall-runoff model, since without this the total runoff volume produced by the model is almost certainly wrong. The river discharge both for Kumbe and Maro River are calculated in the upstream of the irrigated area that can be seen at **Figure 3-6.** The catchment area of the Kumbe River is 3,005 km^2 and for the Maro River is 5,929 km^2.

Figure 3-6 Kumbe and Maro catchment area



Models were calibrated against the Puslitbang flow series (2007-2016) to obtain the soil parameters. And then simulated using Mock method for 30 years according to the existing rainfall data (1990 to 2019).

The full 30-year results are tabulated in **Appendix C in Hydrology Report**, with a summary in **Table 3-18** and illustrated in **Figure 3-7** and **Figure 3-8**. The overall patterns are similar because the simulations use the same rainfall data. The average flows reach their annual minimum by October and approximately double by the end of the year. The other series, however, reach their minimum later and show much less increase by the end of the year. This difference occurs because the average is influenced by a small number of very high flows in November and December, and the magnitude of those flows does not affect the calculation of Q50, Q80 and Q95.

It should be noted that the Mock model calculations are carried out in terms of mm, with the final runoff value being multiplied by the catchment area to give a flow volume. This has been converted to an average flow rate in m^3/s on the basis of a fixed duration of 15.25 days, i.e. assuming an average month length of 30.5 days. In view of all the assumptions made in the analysis it is considered that allowing for the exact number of days in each half-month (including leap years) is not appropriate.

Table 3-18 Summary of simulated flows

(m^3/s)	Kumbe				Maro			
	Average	Q50	Q80	Q95	Average	Q50	Q80	Q95
Jan1	126	84	32	11	244	182	87	27
Jan2	189	214	72	22	347	382	146	50
Feb1	160	159	72	37	292	286	131	69
Feb2	202	161	98	58	361	292	174	108
Mar1	232	204	124	72	412	353	222	127
Mar2	196	160	92	53	345	283	165	90

(m^3/s)	Kumbe				Maro			
	Average	Q50	Q80	Q95	Average	Q50	Q80	Q95
Apr1	199	174	82	64	349	305	143	108
Apr2	192	119	61	38	337	202	107	69
May1	142	107	59	35	247	186	105	64
May2	140	101	60	39	247	175	107	82
Jun1	94	77	50	31	166	133	88	59
Jun2	113	75	48	29	200	129	85	57
Jul1	92	64	44	27	167	118	82	54
Jul2	65	58	38	23	118	103	72	46
Aug1	65	53	34	20	123	101	65	42
Aug2	58	49	35	19	113	95	68	39
Sep1	50	43	31	17	96	85	62	36
Sep2	49	41	29	15	98	80	57	33
Oct1	48	40	26	14	98	78	52	30
Oct2	78	36	23	12	151	73	49	28
Nov1	74	37	22	11	146	75	45	26
Nov2	109	36	19	10	206	73	41	24
Dec1	85	40	21	12	168	86	46	27
Dec2	101	43	20	13	193	106	46	28
Average	119	91	50	28	217	166	94	55
Annual	119	106	75	43	217	194	140	84

Figure 3-7 Simulated flow patterns – Kumbe River

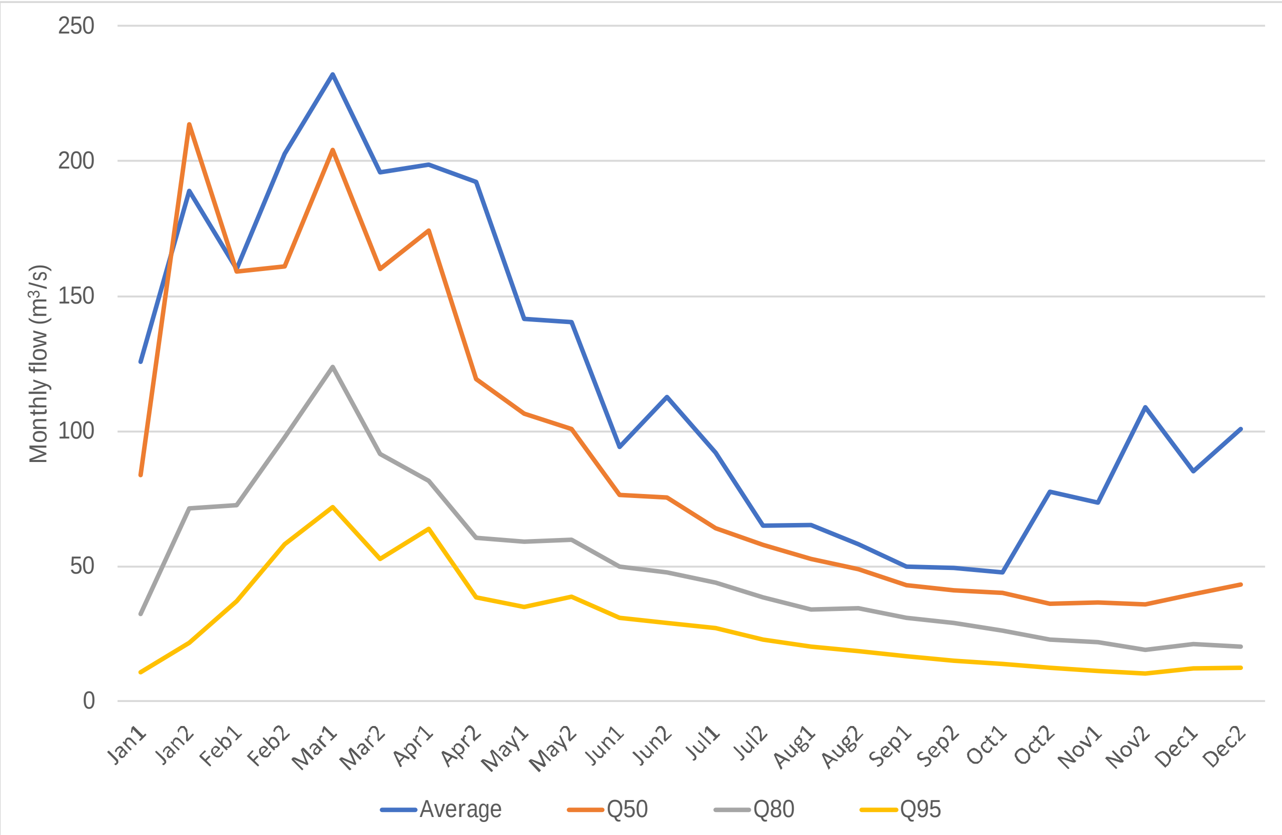
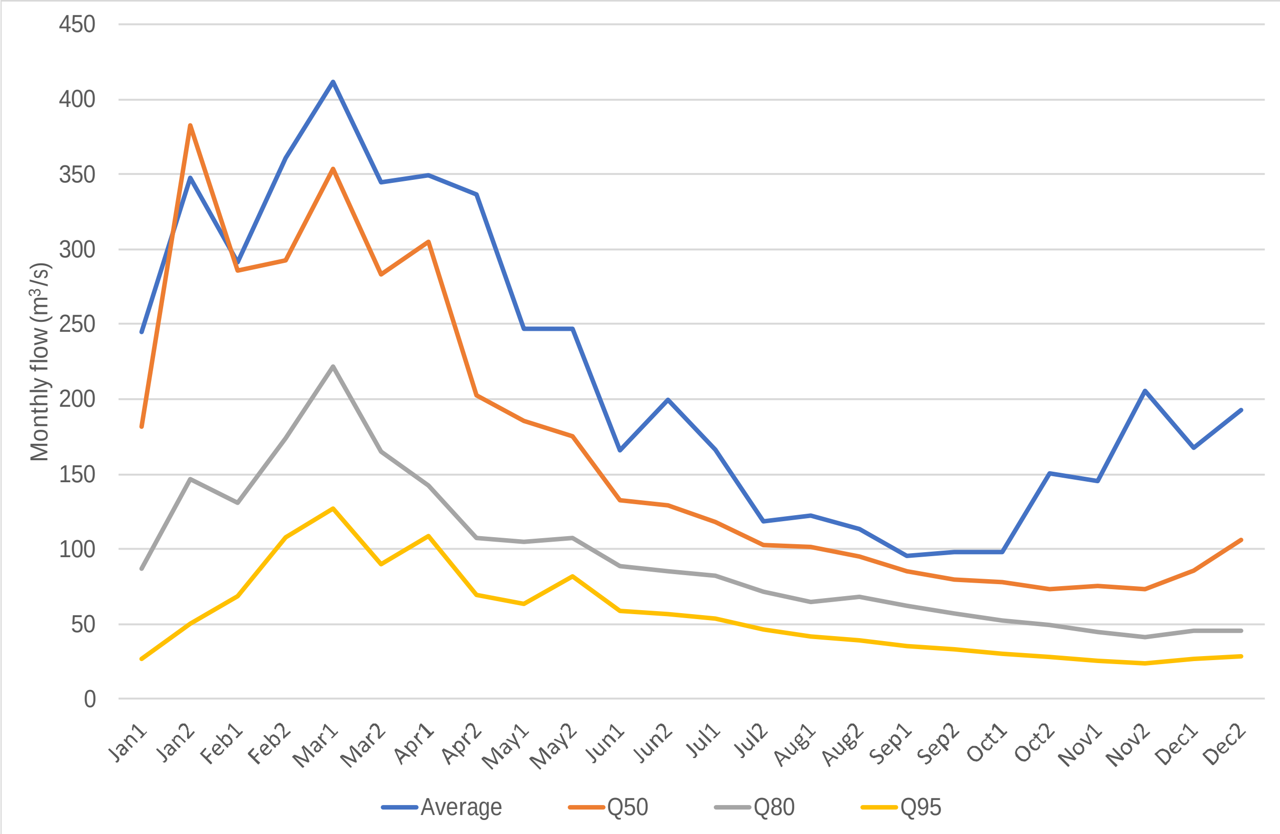


Figure 3-8 Simulated flow patterns – Maro River



3.4.6 Hydro-topography and water conservation

3.4.6.1 Hydro-topographic categories

Most tidal lowlands are at an elevation close to the average spring-tide high water-level. The tidal range along the coasts of South Papua is 4.3-4.6 m. The elevation of the land in relation to the nearby river levels is of vital importance to the potential for development as it determines whether the land can be adequately drained and protected against floods, and, outside the zone of saline water intrusion, the possibilities for tidal irrigation. Four hydro-topographical categories are distinguished as shown below and in **Figure 3-9** from the boundary of the tidal lowland areas defined by DGWR in 2014-2015.

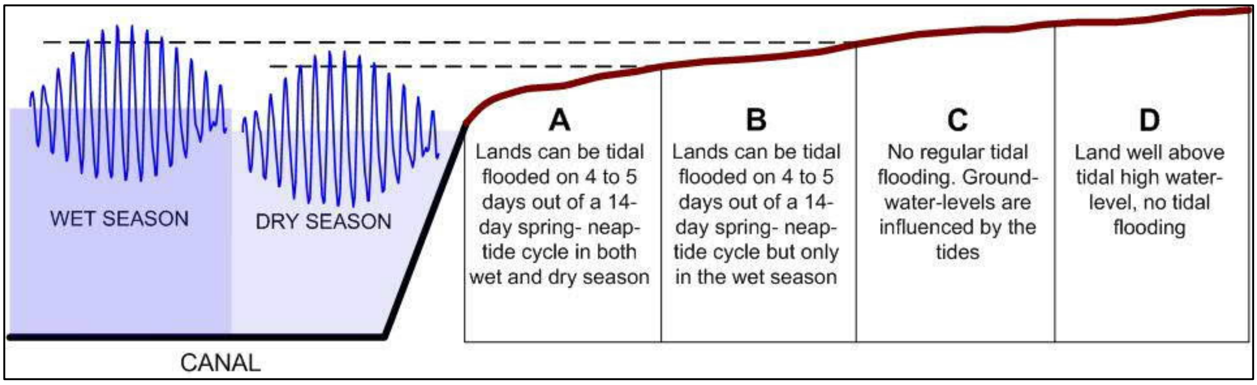
Category A Tidal irrigated areas: areas which can be flooded by the tides at least 4 or 5 times during a 14-day neap-spring tide cycle in both the wet and the dry season.

Category B Periodically tidal irrigated areas: areas which can be flooded by the tides at least 4 or 5 times during a 14-day neap-spring tide cycle, but only so in the wet season.

Category C Areas just above tidal high water: areas which cannot be regularly flooded during high tide, although the groundwater table may still be influenced by the tides.

Category D Upland areas: areas which are entirely above tidal influence.

Figure 3-9 Four hydro-topographic categories



3.4.6.2 Kurik Lowland Irrigation Scheme

Kurik LL irrigation scheme covers the area of 14,700 Ha, consists of 6 main sub-schemes under the Central Government, namely Kurik 1, 2, 3, 4, 5, and 6. Kumbe LL Irrigation scheme that is under the responsibility of Merauke District, also put in this section.

The hydro topographic condition of the area is categorized as C and D, as shown in **Figure 3-10 - Figure 3-14.** The area influenced by the tidal water levels; but never been flooded by the tide. Most of land of the area has 1 m higher from the tide water level. A small part of Kurik LL Irrigation scheme has higher land level of more than 4 m above the river average water level.

Table 3-19 shows the field water balance of the Kurik LL Irrigation Scheme. As the conservation/ drainage canals directly connected to the primary canals on one side, and the river on the other side, water is always available in that canals. Farmers only have to lift water using simple pumps to bring water for their land. Basically, water from the conservation /drainage canals would be the major supply for irrigating the field, as it provides of about 75% of total water supply.

The rest of 25% will be fulfilled using the supply system through the secondary canals. To flow water from the primary to the secondaries requires low lift pumps to provide flow energy to distribute water to the tertiaries and then to the field by gravity.

Figure 3-10 Hydro topographic Map of Kurik 1

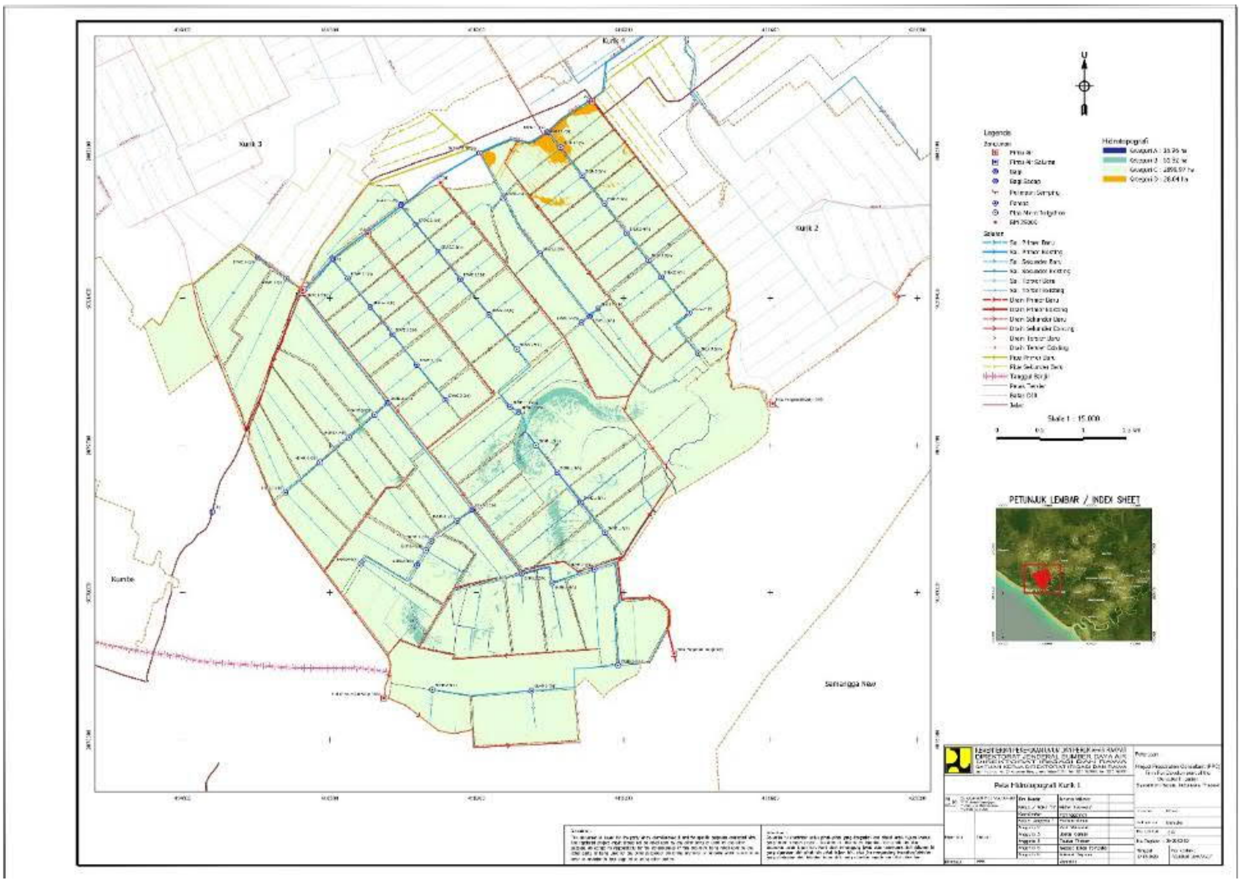


Figure 3-11 Hydro topographic Map of Kurik 2

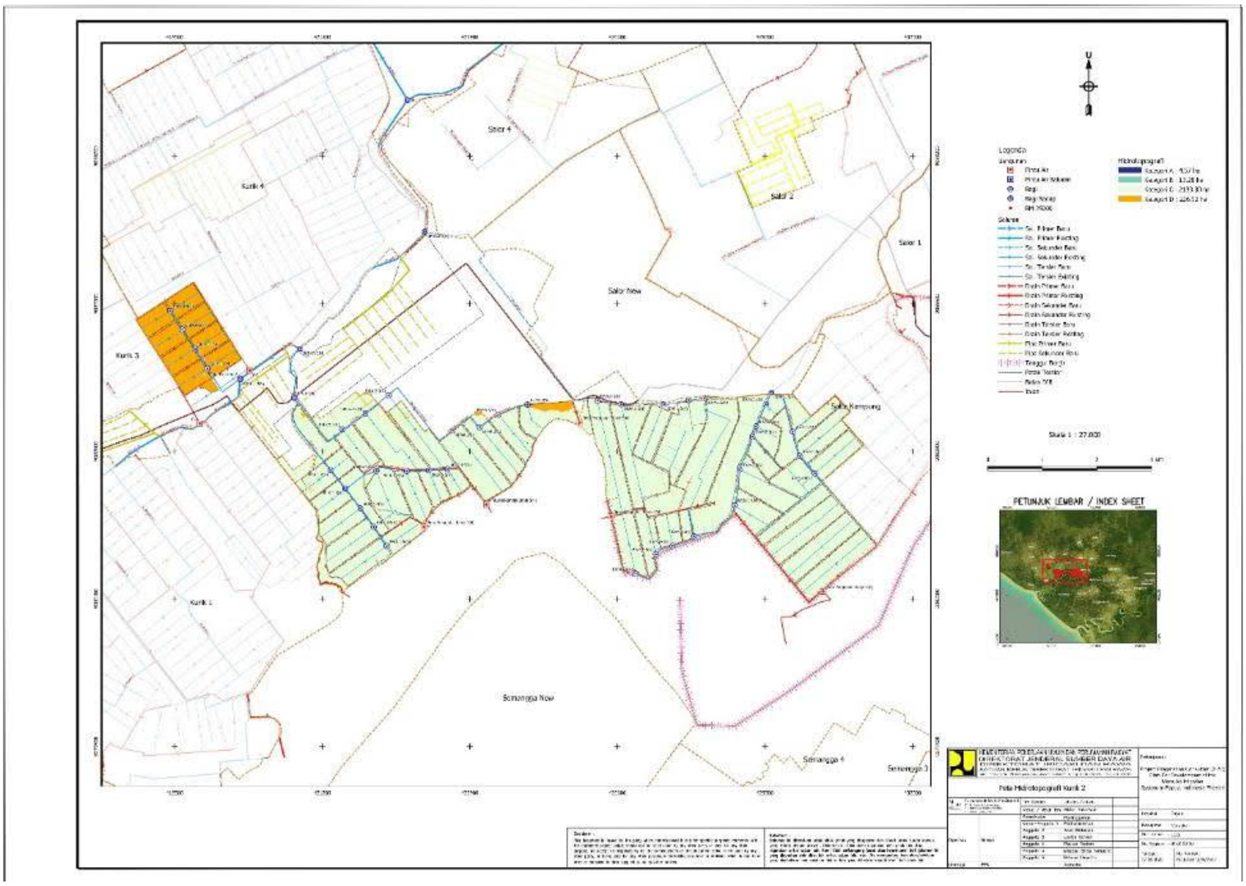


Figure 3-12 Hydro topographic Map of Kurik 5

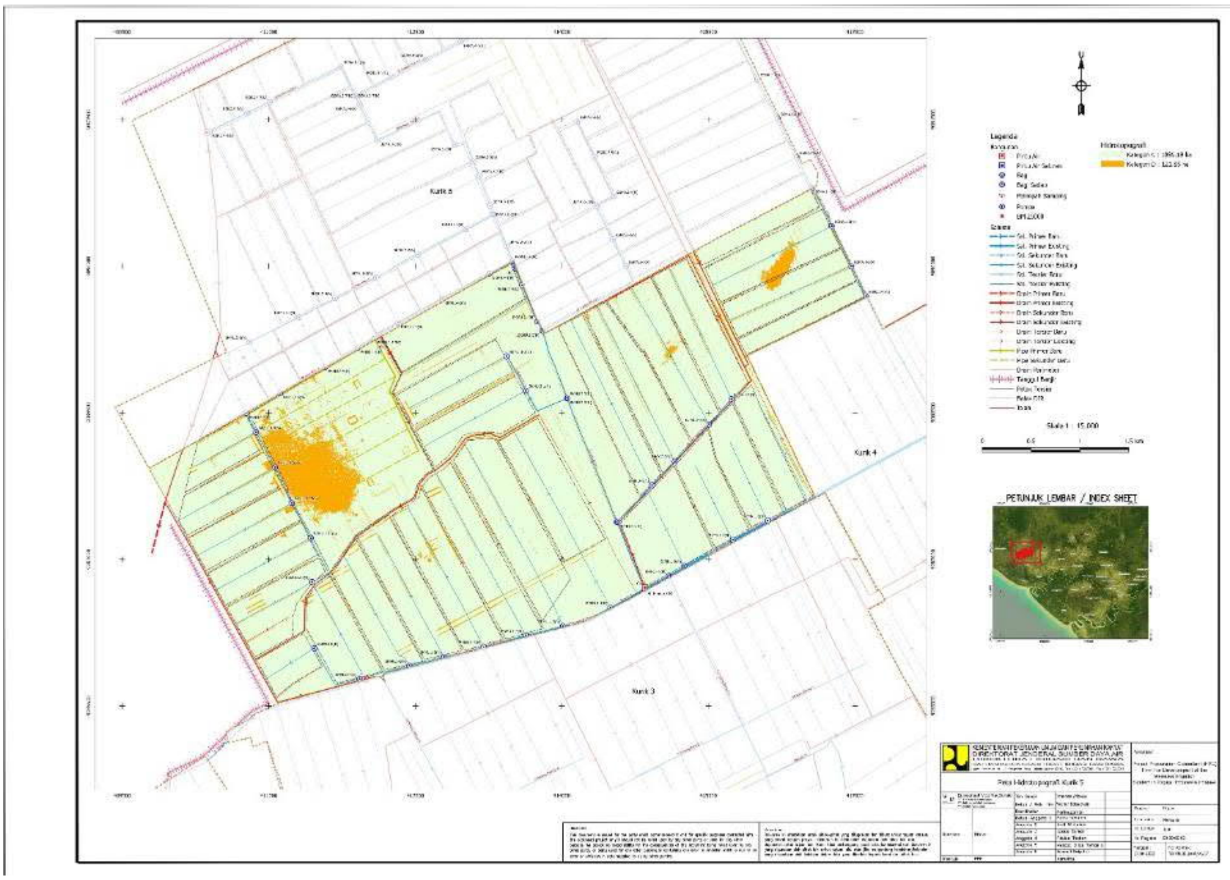


Figure 3-13 Hydro topographic Map of Kurik 6

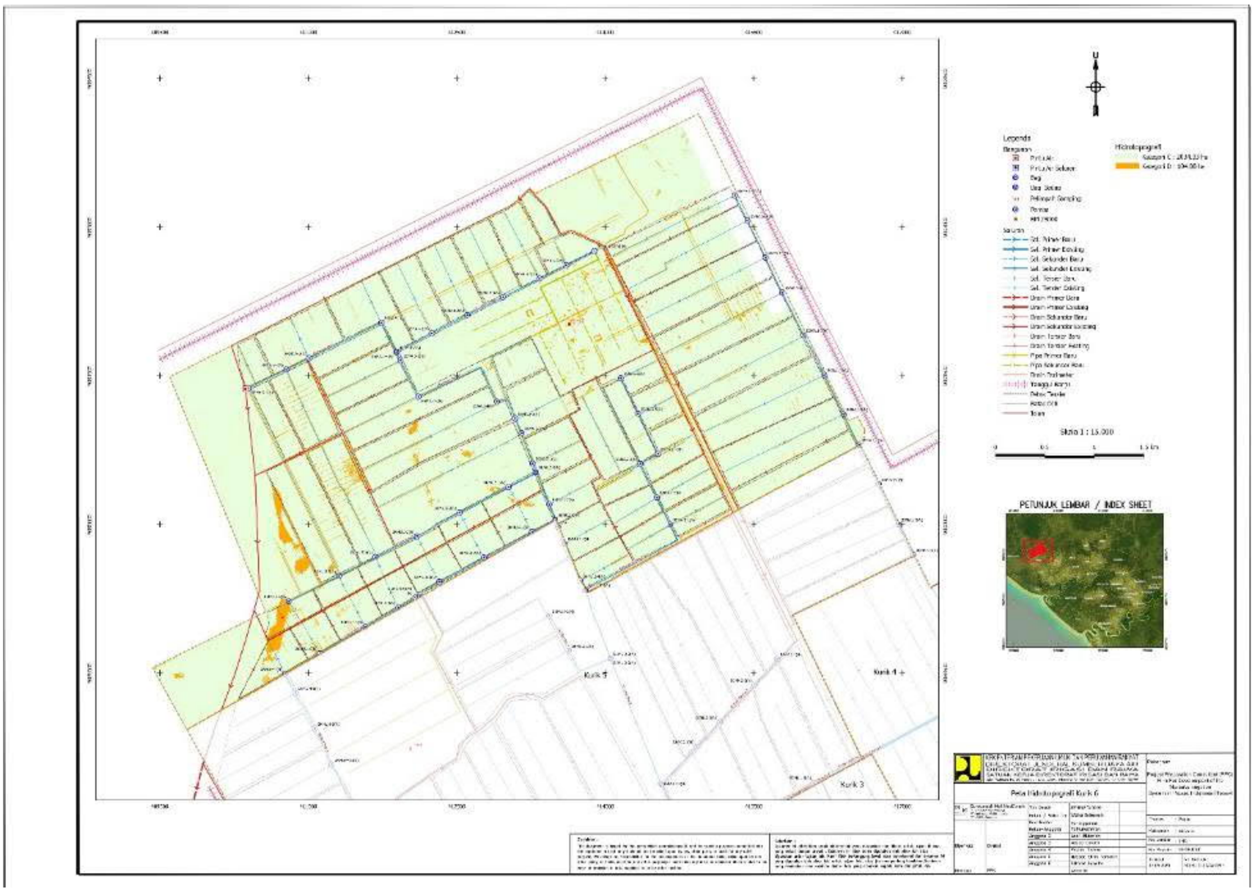


Figure 3-14 Hydro topographic Map of Kumbe Kampung

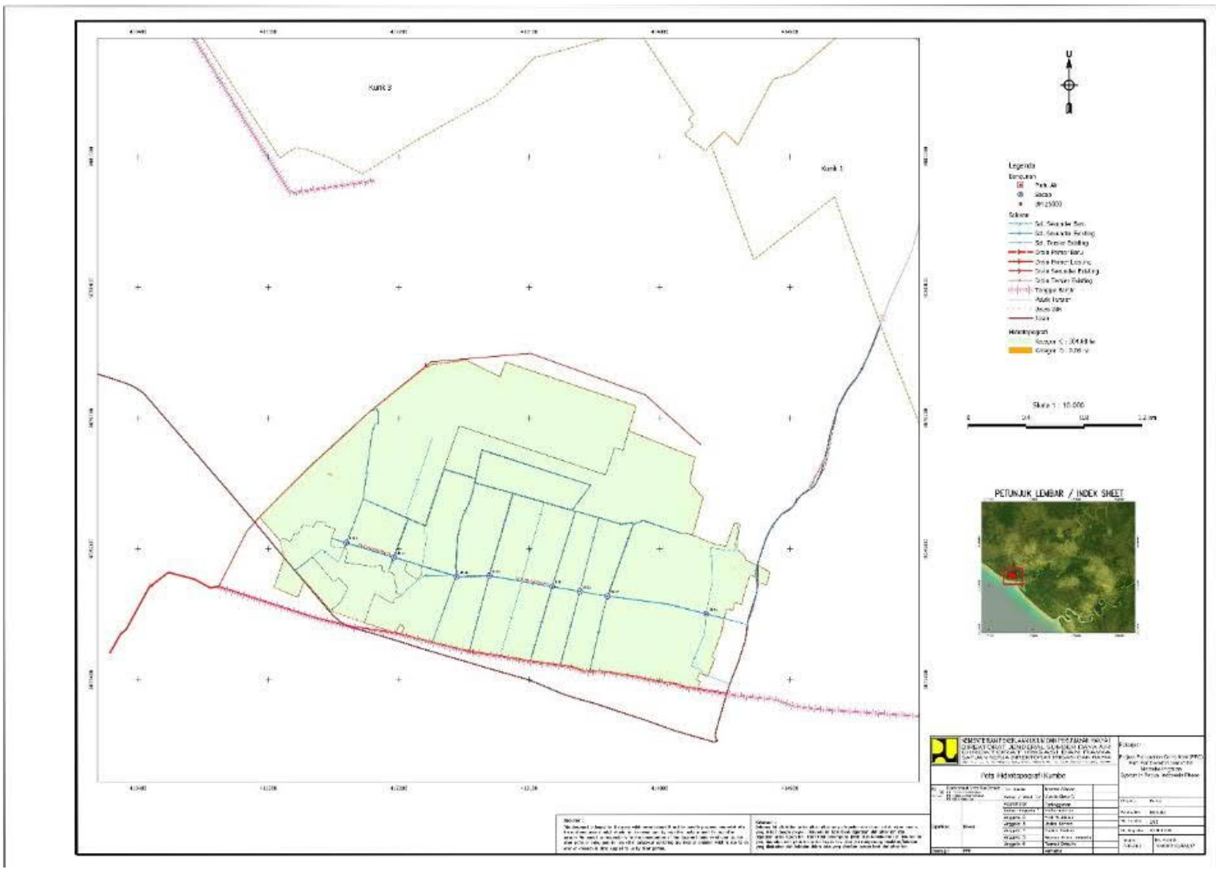


Table 3-19 Field water balance of Kurik and Kumbe lowland irrigation schemes

	Describes:																										
	a) Irrigation water requirements																										
	b) how much water from the supply system																										
	c) how much water from the storage plus additional from primary																										
I t e m				**Des**		**Jan**		**Feb**		**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**	
				15	16	15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15
A	**Water Requirements and Water Supply**																										
A.1	**DATA**																										
	Water requirements		(l /s/ha)	0.16	0.43	0.00	0.25	0.77	0.57	0.24	0.21	0.00	0.29	0.23	0.86	1.24	1.16	1.07	0.71	0.29	0.40	0.66	0.77	0.80	0.59	0.18	0.00
			(m3/s/1000ha)																								
A.2	**Water requirements for each scheme:**	Area (Ha)	(m3/s)																								
	Salor 1,2,3,4	4,532		0.74	1.93	0	1.14	3.47	2.58	1.07	0.94	0	1.33	1.06	3.91	5.61	5.24	4.86	3.23	1.30	1.83	3.01	3.49	3.64	2.68	0.83	0
	SP1 Kurik	5,663		0.93	2.41	0	1.43	4.34	3.22	1.33	1.18	0	1.66	1.32	4.89	7.01	6.54	6.08	4.04	1.63	2.29	3.76	4.36	4.55	3.35	1.03	0
	SP2 Kurik	8,455		1.39	3.60	0	2.14	6.48	4.80	1.99	1.76	0	2.48	1.97	7.30	10.46	9.77	9.07	6.02	2.43	3.42	5.62	6.50	6.80	5.00	1.54	0
	Total field requirements		(m3/s)	***3.06***	***7.94***	***0***	***4.71***	***14.28***	***10.60***	***4.39***	***3.89***	***0***	***5.46***	***4.35***	***16.10***	***23.08***	***21.55***	***20.01***	***13.29***	***5.37***	***7.54***	***12.39***	***14.34***	***15.00***	***11.03***	***3.40***	***0***
		18,650	MCM	3.97	10.29	0	6.10	18.51	13.74	5.69	5.04	0	7.08	5.63	20.87	29.91	27.93	25.93	17.22	6.96	9.77	16.06	18.59	19.44	14.29	4.40	0
A.3	**Water from the supply canal system**																										
	Net water reqirements at primary canals		(l/s/ha)	0	0	0	0	0	0	0	0	0	0	0	0.06	0.44	0.36	0.27	0.00	0	0	0	0	0.004	0	0	0
		Area (Ha)																									
	> Supletion canal command area	18,650	(m3/s)	0	0	0	0	0	0	0	0	0	0	0	1.18	8.16	6.63	5.09	0.00	0	0	0	0	0	0	0	0
	> Kurik 1 primary command area	5,663	(m3/s)	0	0	0	0	0	0	0	0	0	0	0	0.36	2.48	2.01	1.54	0.00	0	0	0	0	0	0	0	0
	> Kurik 2 primary command area	8,455	(m3/s)	0	0	0	0	0	0	0	0	0	0	0	0.54	3.70	3.01	2.31	0.00	0	0	0	0	0	0	0	0
	Total water required from the supply canal system		(m3/s)	0	0	0	0	0	0	0	0	0	0	0	1.18	8.16	6.63	5.09	0.00	0	0	0	0	0	0	0	0
	with pumping through secondary supply canals		MCM	0	0	0	0	0	0	0	0	0	0	0	1.53	10.57	8.60	6.59	0.00	0	0	0	0	0	0	0	0
A.4	**Water from the field storage (part from rainfall, and the other part from the canal)**																										
		Area (Ha)	(l/s/ha)	0.16	0.43	0	0.25	0.77	0.57	0.24	0.21	0	0.29	0.23	0.80	0.80	0.80	0.80	0.71	0.29	0.40	0.66	0.77	0.80	0.59	0.18	0
	> Salor 1, 2, 3 and 4	4,532	(m3/s)	0.74	1.93	0	1.14	3.47	2.58	1.07	0.94	0	1.33	1.06	3.63	3.63	3.63	3.63	3.23	1.30	1.83	3.01	3.49	3.63	2.68	0.83	0
	Kurik 1 primary command area	5,663	(m3/s)	0.93	2.41	0	1.43	4.34	3.22	1.33	1.18	0	1.66	1.32	4.53	4.53	4.53	4.53	4.04	1.63	2.29	3.76	4.36	4.53	3.35	1.03	0
	Kurik 2 primary command area	8,455	(m3/s)	1.39	3.60	0	2.14	6.48	4.80	1.99	1.76	0	2.48	1.97	6.76	6.76	6.76	6.76	6.02	2.43	3.42	5.62	6.50	6.76	5.00	1.54	0
	Total water required from the field storage		(m3/s)	3.06	7.94	0	4.71	14.28	10.60	4.39	3.89	0	5.46	4.35	14.92	14.92	14.92	14.92	13.29	5.37	7.54	12.39	14.34	14.92	11.03	3.40	0
			MCM	3.97	10.29	0	6.10	18.51	13.74	5.69	5.04	0	7.08	5.63	19.34	19.34	19.34	19.34	17.22	6.96	9.77	16.06	18.59	19.34	14.29	4.40	0

Table 3-20 Water from drain canal alone (Kurik) & water from primary canals

Describes:
a) How much water water from field storage /drain canals alone
b) How much water delivered to the field storage/drain canals by primary canals

I t e m				Des		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
B.	**Field storage capacity & additional supply from primary cnl**																										
B.2	**Kurik - Primary Canal 1**	5,663	Ha																								
	> Rainfall (50% probability)		mm	43.5	74.4	99.8	181.6	137.2	156.4	163	139	112.5	69.2	49.9	26.6	10.9	14.5	13.3	7.7	4.4	3.1	1.1	1.7	2.6	2.5	5.9	10.9
Tersedia	> Avail.water in drain cnls can be utilized for irr. (mm)		mm	32.63	55.80	74.85	136.20	102.90	117.30	122.25	104.25	84.38	51.90	37.43	19.95	8.18	10.88	9.98	5.78	3.30	2.33	0.83	1.28	1.95	1.88	4.43	8.18
	in MCM		MCM	1.85	3.16	4.24	7.71	5.83	6.64	6.92	5.90	4.78	2.94	2.12	1.13	0.46	0.62	0.56	0.33	0.19	0.13	0.05	0.07	0.11	0.11	0.25	0.46
Kebth	> Total water required from the field storage		(m3/s)	0.93	2.41	0.00	1.43	4.34	3.22	1.33	1.18	0.00	1.66	1.32	4.53	4.53	4.53	4.53	4.04	1.63	2.29	3.76	4.36	4.53	3.35	1.03	0.00
	This is based on the assumption that Wreq <0.8 l/s/ha is		MCM	1.21	3.13	0.00	1.85	5.62	4.17	1.73	1.53	0.00	2.15	1.71	5.87	5.87	5.87	5.87	5.23	2.11	2.97	4.88	5.64	5.87	4.34	1.34	0.00
	fulfilled by the field storage																										
Kurang	> Additional water required (MCM)		MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.74	5.41	5.26	5.31	4.90	1.93	2.83	4.83	5.57	5.76	4.23	1.09	0.00
	(water provided by the primary cnl, by gravity flows)		m3/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66	4.17	4.06	4.09	3.78	1.49	2.19	3.73	4.30	4.45	3.27	0.84	0.00
B.3	**Kurik - Primary Canal 2**	8,455	Ha																								
	> Rainfall (50% probability)		mm	43.5	74.4	99.8	181.6	137.2	156.4	163	139	112.5	69.2	49.9	26.6	10.9	14.5	13.3	7.7	4.4	3.1	1.1	1.7	2.6	2.5	5.9	10.9
Tersedia	> Avail.water in drain cnls can be utilized for irr. (mm)		mm	32.63	55.80	74.85	136.20	102.90	117.30	122.25	104.25	84.38	51.90	37.43	19.95	8.18	10.88	9.98	5.78	3.30	2.33	0.83	1.28	1.95	1.88	4.43	8.18
	in MCM		MCM	2.76	4.72	6.33	11.52	8.70	9.92	10.34	8.81	7.13	4.39	3.16	1.69	0.69	0.92	0.84	0.49	0.28	0.20	0.07	0.11	0.16	0.16	0.37	0.69
Kebth	> Total water required from the field storage		(m3/s)	1.39	3.60	0.00	2.14	6.48	4.80	1.99	1.76	0.00	2.48	1.97	6.76	6.76	6.76	6.76	6.02	2.43	3.42	5.62	6.50	6.76	5.00	1.54	0.00
	This is based on the assumption that Wreq <0.8 l/s/ha is		MCM	1.80	4.67	0.00	2.77	8.39	6.23	2.58	2.28	0.00	3.21	2.55	8.77	8.77	8.77	8.77	7.81	3.16	4.43	7.28	8.43	8.77	6.48	2.00	0.00
	fulfilled by the field storage																										
Kurang	> Additional water required (MCM)		MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.08	8.07	7.85	7.92	7.32	2.88	4.23	7.21	8.32	8.60	6.32	1.62	0.00
	(water provided by the primary cnl, by gravity flows)		m3/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.46	6.23	6.05	6.11	5.65	2.22	3.27	5.56	6.42	6.64	4.88	1.25	0.00
B.4	**Kurik Salor**	18,650	Ha																								
	> Rainfall (50% probability)		mm	43.5	74.4	99.8	181.6	137.2	156.4	163	139	112.5	69.2	49.9	26.6	10.9	14.5	13.3	7.7	4.4	3.1	1.1	1.7	2.6	2.5	5.9	10.9
Tersedia	> Avail.water in drain cnls can be utilized for irr. (mm)		mm	32.63	55.80	74.85	136.20	102.90	117.30	122.25	104.25	84.38	51.90	37.43	19.95	8.18	10.88	9.98	5.78	3.30	2.33	0.83	1.28	1.95	1.88	4.43	8.18
	in MCM		MCM	6.08	10.41	13.96	25.40	19.19	21.88	22.80	19.44	15.74	9.68	6.98	3.72	1.52	2.03	1.86	1.08	0.62	0.43	0.15	0.24	0.36	0.35	0.83	1.52
Kebth	> Total water required from the field storage		(m3/s)	3.06	7.94	0.00	4.71	14.28	10.60	4.39	3.89	0.00	5.46	4.35	14.92	14.92	14.92	14.92	13.29	5.37	7.54	12.39	14.34	14.92	11.03	3.40	0.00
	This is based on the assumption that Wreq <0.8 l/s/ha is		MCM	3.97	10.29	0.00	6.10	18.51	13.74	5.69	5.04	0.00	7.08	5.63	19.34	19.34	19.34	19.34	17.22	6.96	9.77	16.06	18.59	19.34	14.29	4.40	0.00
	fulfilled by the field storage																										
Kurang	> Additional water required (MCM)		MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.62	17.81	17.31	17.48	16.15	6.34	9.33	15.90	18.35	18.97	13.94	3.58	0.00
	(water provided by the primary cnl, by gravity flows)		m3/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.05	13.74	13.36	13.48	12.46	4.90	7.20	12.27	14.16	14.64	10.76	2.76	0.00

Table 3-21 Water in supply canal & drainage cum storage

I t e m				Des		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
C.	Water supply in the supletion & primary																										
C.2	Along the Kurik 1 Primary canal	5,663	Ha																								
	For supply canals		(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	2.48	2.01	1.54	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
			(MCM)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	3.21	2.61	2.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
	For drainage cum storage		(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.66	4.17	4.06	4.09	3.78	1.49	2.19	3.73	4.30	4.45	3.27	0.84	0.00
			(MCM)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.74	5.41	5.26	5.31	4.90	1.93	2.83	4.83	5.57	5.76	4.23	1.09	0.00
	Pemompaan per petak tersier (l/s)	8 Hrs/day	(l/s/tersier)												97	111	107	108	100	39	58	99	114	118	87	22	
	Jumlah petak tersier	113																									
C.3	Along the Kurik 2 Primary canal	8455	Ha																								
	For supply canals		(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	3.70	3.01	2.31	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
			(MCM)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	4.79	3.90	2.99	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00
	For drainage cum storage		(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.46	6.23	6.05	6.11	5.65	2.22	3.27	5.56	6.42	6.64	4.88	1.25	0.00
			(MCM)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.08	8.07	7.85	7.92	7.32	2.88	4.23	7.21	8.32	8.60	6.32	1.62	0.00
	Pemompaan per petak tersier (l/s)		(l/s/tersier)												97	111	107	108	100	39	58	99	114	118	87	22	
	Jumlah petak tersier	169																									

Table 3-22 The rate of pumping

I t e m				Des		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
D	Water supply from the primary canals																										
C.2	Along the Kurik 1 Primary canal	5,663	Ha																								
		Continuous	(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	2.48	2.01	1.54	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
		Intermittenly	(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	4.95	4.03	3.09	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00
		Avg cap/pump	(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.83	0.67	0.51	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
		Per 1000 Ha	(l/s)	-	-	-	-	-	-	-	-	-	-	-	127	875	711	546	-	-	-	-	-	8	-	-	-
C.3	Along the Kurik 2 Primary canal	8,455	Ha																								
		Continuous	(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	3.70	3.01	2.31	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
		Intermittenly	(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	7.40	6.01	4.61	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
		Avg cap/pump	(m3/s)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	1.23	1.00	0.77	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
		Per 1000 Ha	(l/s)	-	-	-	-	-	-	-	-	-	-	-	189	1,306	1,062	815	-	-	-	-	-	12	-	-	-

3.4.6.3 Salor lowland irrigation scheme

Salor LL irrigation scheme consists of four sub-schemes, namely Salor 1, 2, 3 and 4 and Salor Kampung. covers the area of 4,532 ha. The sub-schemes are under the Central Government, except for Salor Kampung that is under the responsibility of Merauke District Government.

The hydro-topographic condition of the area of Salor is also categorized as C and D, just like Kurik scheme, as shown in **Figure 3-15.** The Salor 2 and 4 has higher land level compared with the rest of the area although some 150 ha of Salor 3 is also high.

Figure 3-15 Hydro-topographic map of Salor lowland irrigation scheme

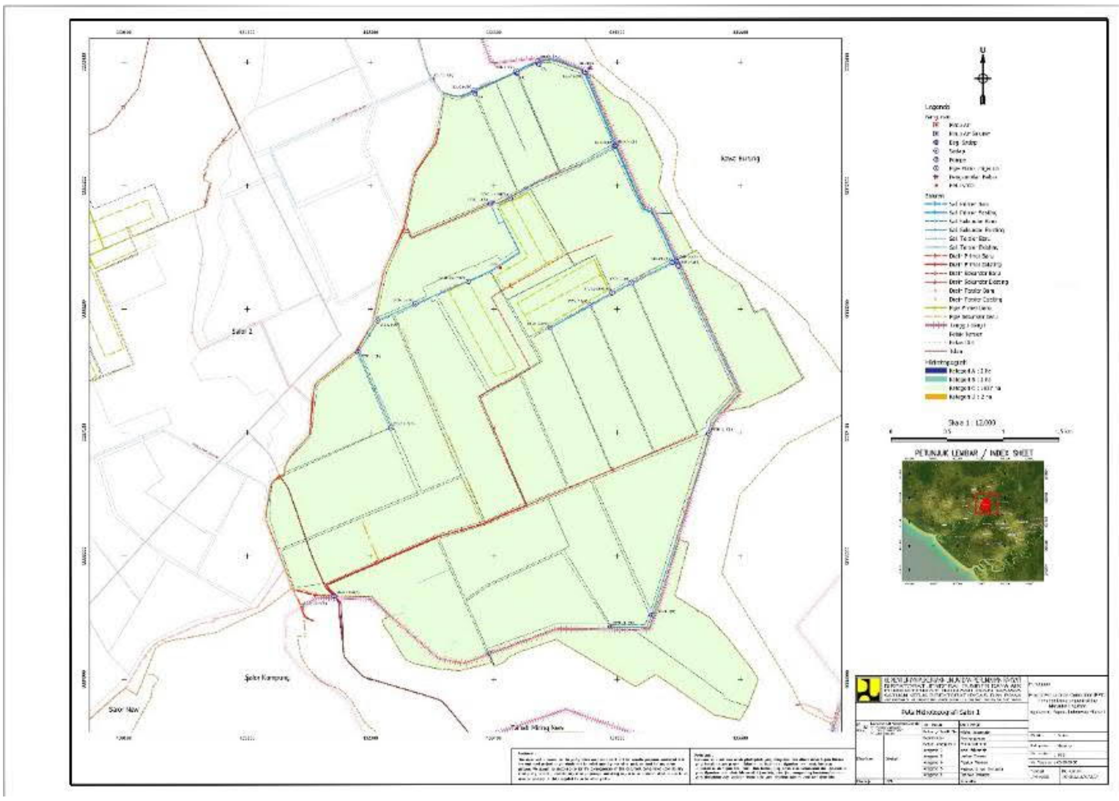


Figure 3-16 Hydro-topographic map of Salor 2 & 4

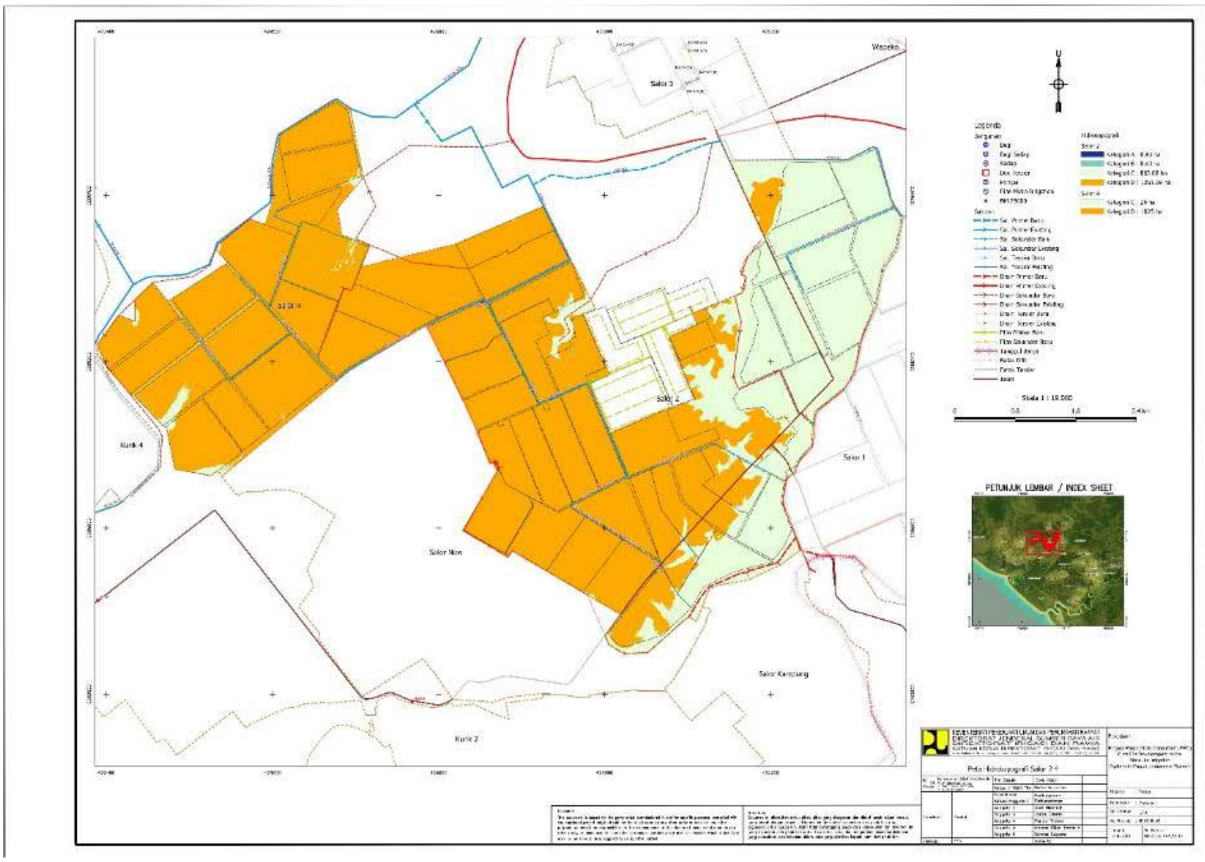


Figure 3-17 Hydro-topographic map of Salor 2 & 4

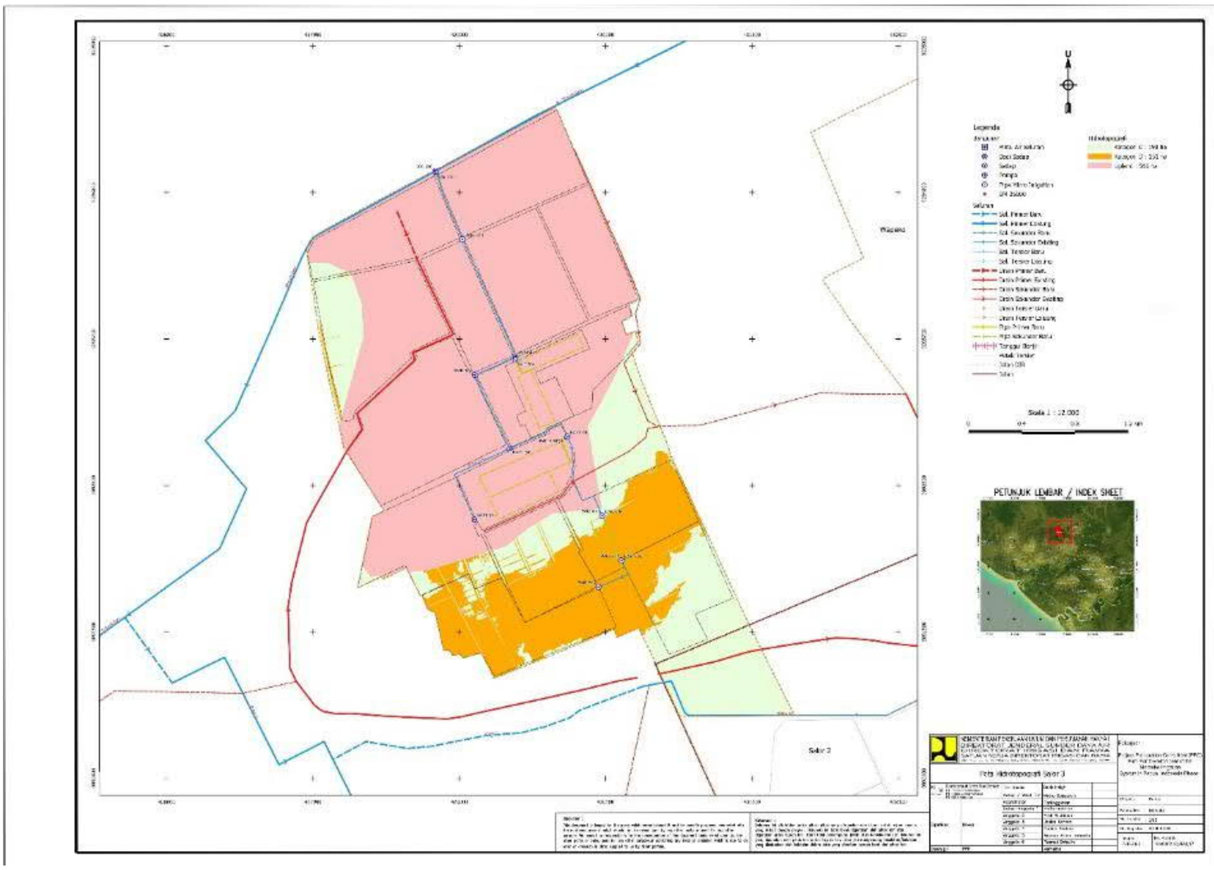


Figure 3-18 Hydro-topographic map of Salor Kampung

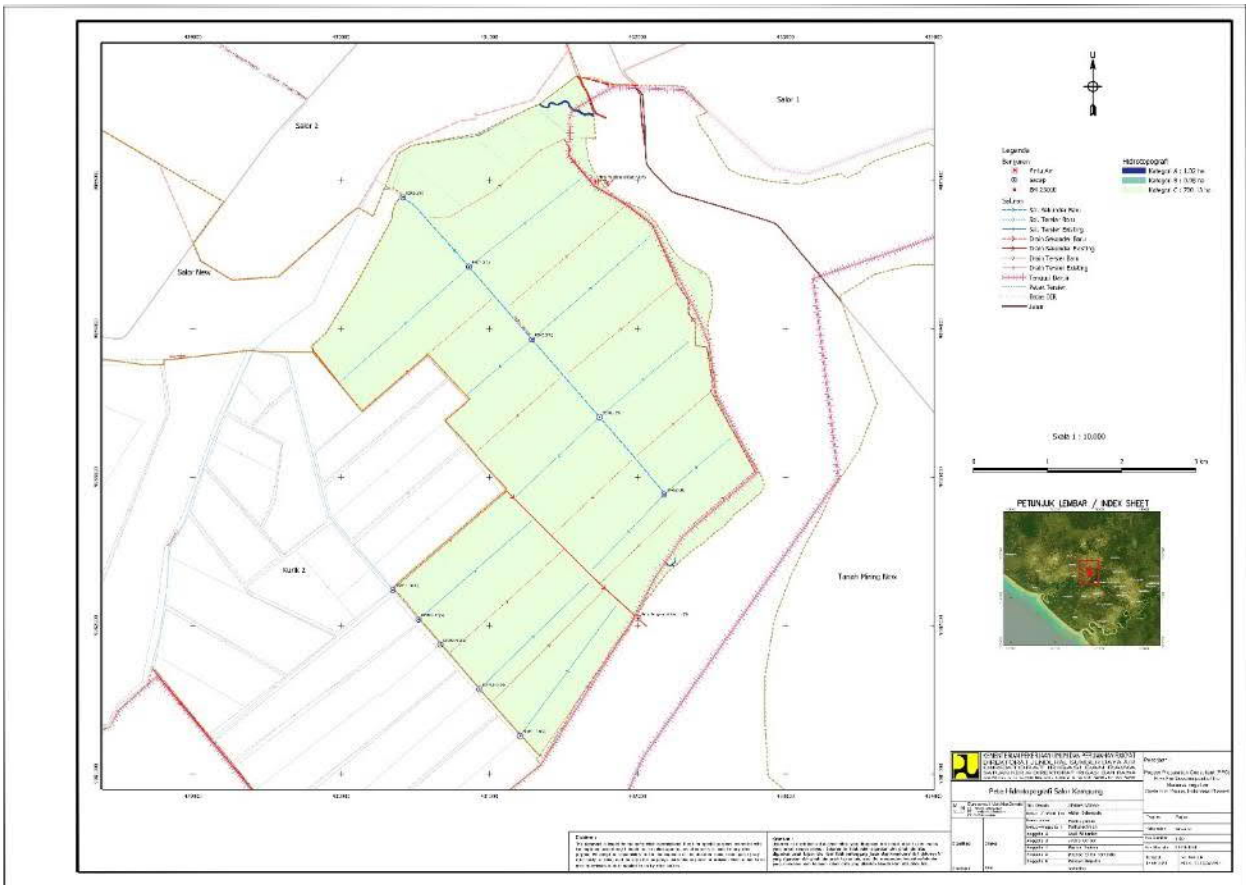


Table 3-23 Field water balance of Salor lowland irrigation scheme

	Describes:																										
	a) Irrigation water requirements																										
	b) how much water from the supply system																										
	c) how much water from the storage plus additional from primary																										
	I t e m			Des		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
				15	16	15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15
A	**Water Requirements and Water Supply**																										
A.1	**DATA**																										
	Water requirements		(l /s/ha)	0.16	0.43	0.00	0.25	0.77	0.57	0.24	0.21	0.00	0.29	0.23	0.86	1.24	1.16	1.07	0.71	0.29	0.40	0.66	0.77	0.80	0.59	0.18	0.00
			(m3/s/1000ha)																								
A.2	**Water requirements for each scheme:**	Area (Ha)	(m3/s)																								
	Salor 1,2,3,4	4,532		0.74	1.93	0	1.14	3.47	2.58	1.07	0.94	0	1.33	1.06	3.91	5.61	5.24	4.86	3.23	1.30	1.83	3.01	3.49	3.64	2.68	0.83	0
	SP1 Kurik	5,663		0.93	2.41	0	1.43	4.34	3.22	1.33	1.18	0	1.66	1.32	4.89	7.01	6.54	6.08	4.04	1.63	2.29	3.76	4.36	4.55	3.35	1.03	0
	SP2 Kurik	8,455		1.39	3.60	0	2.14	6.48	4.80	1.99	1.76	0	2.48	1.97	7.30	10.46	9.77	9.07	6.02	2.43	3.42	5.62	6.50	6.80	5.00	1.54	0
	Total field requirements		(m3/s)	***3.06***	***7.94***	***0***	***4.71***	***14.28***	***10.60***	***4.39***	***3.89***	***0***	***5.46***	***4.35***	***16.10***	***23.08***	***21.55***	***20.01***	***13.29***	***5.37***	***7.54***	***12.39***	***14.34***	***15.00***	***11.03***	***3.40***	***0***
A.4	**Water from the field storage (part from rainfall, and the other part from the canal)**																										
		Area (Ha)	(l/s/ha)	0.16	0.43	0	0.25	0.77	0.57	0.24	0.21	0	0.29	0.23	0.80	0.80	0.80	0.80	0.71	0.29	0.40	0.66	0.77	0.80	0.59	0.18	0
	> Salor 1, 2, 3 and 4	4,532	(m3/s)	0.74	1.93	0	1.14	3.47	2.58	1.07	0.94	0	1.33	1.06	3.63	3.63	3.63	3.63	3.23	1.30	1.83	3.01	3.49	3.63	2.68	0.83	0
	Kurik 1 primary command area	5,663	(m3/s)	0.93	2.41	0	1.43	4.34	3.22	1.33	1.18	0	1.66	1.32	4.53	4.53	4.53	4.53	4.04	1.63	2.29	3.76	4.36	4.53	3.35	1.03	0
	Kurik 2 primary command area	8,455	(m3/s)	1.39	3.60	0	2.14	6.48	4.80	1.99	1.76	0	2.48	1.97	6.76	6.76	6.76	6.76	6.02	2.43	3.42	5.62	6.50	6.76	5.00	1.54	0
	Total water required from the field storage		(m3/s)	3.06	7.94	0	4.71	14.28	10.60	4.39	3.89	0	5.46	4.35	14.92	14.92	14.92	14.92	13.29	5.37	7.54	12.39	14.34	14.92	11.03	3.40	0
			MCM	3.97	10.29	0	6.10	18.51	13.74	5.69	5.04	0	7.08	5.63	19.34	19.34	19.34	19.34	17.22	6.96	9.77	16.06	18.59	19.34	14.29	4.40	0

Table 3-24 Water from drain canal alone (Salor) & water from primary canals

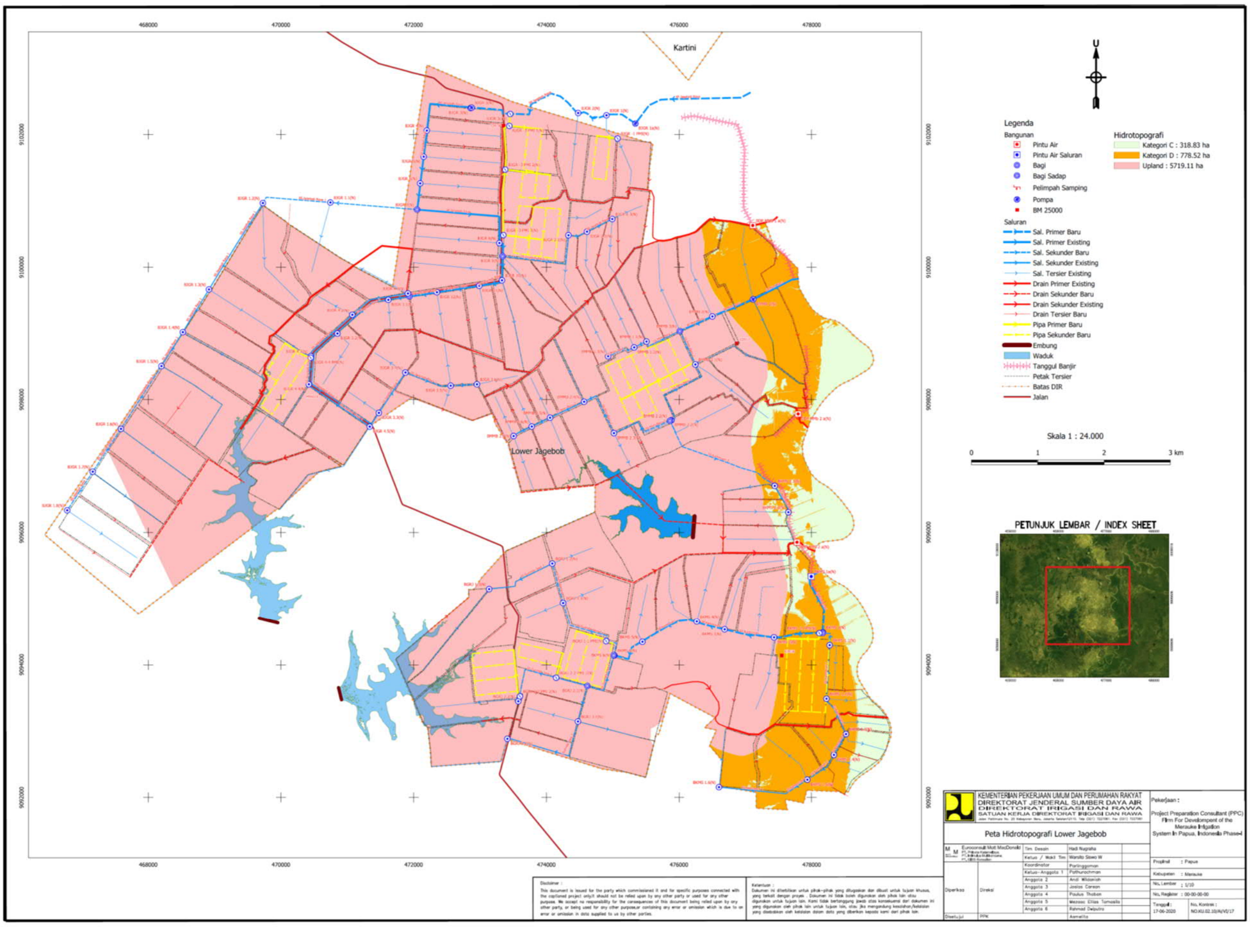
	Describes:																										
	a) How much water water from field storage /drain canals alone																										
	b) How much water delivered to the field storage/drain canals by primary canals																										
	I t e m			Des		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
B.	**Field storage capacity & additional supply from primary cnl**																										
B.1	**Salor 1, 2, 3**	4,532	Ha																								
	> Rainfall (50% probability)		mm	43.5	74.4	99.8	181.6	137.2	156.4	163	139	112.5	69.2	49.9	26.6	10.9	14.5	13.3	7.7	4.4	3.1	1.1	1.7	2.6	2.5	5.9	10.9
Tersedia	> Avail.water in drain cnls can be utilized for irr. (mm)		mm	32.63	55.80	74.85	136.20	102.90	117.30	122.25	104.25	84.38	51.90	37.43	19.95	8.18	10.88	9.98	5.78	3.30	2.33	0.83	1.28	1.95	1.88	4.43	8.18
	in MCM		MCM	1.48	2.53	3.39	6.17	4.66	5.32	5.54	4.72	3.82	2.35	1.70	0.90	0.37	0.49	0.45	0.26	0.15	0.11	0.04	0.06	0.09	0.08	0.20	0.37
Kebth	> Total water required from the field storage		(m3/s)	0.74	1.93	0.00	1.14	3.47	2.58	1.07	0.94	0.00	1.33	1.06	3.63	3.63	3.63	3.63	3.23	1.30	1.83	3.01	3.49	3.63	2.68	0.83	0.00
	This is based on the assumption that Wreq <0.8 l/s/ha is		MCM	0.96	2.50	0.00	1.48	4.50	3.34	1.38	1.22	0.00	1.72	1.37	4.70	4.70	4.70	4.70	4.19	1.69	2.37	3.90	4.52	4.70	3.47	1.07	0.00
	fulfilled by the field storage																										
Kurang	> Additional water required (MCM)		MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.79	4.33	4.21	4.25	3.92	1.54	2.27	3.86	4.46	4.61	3.39	0.87	0.00
	(water provided by the primary cnl, gravity flows)		m3/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.93	3.34	3.25	3.28	3.03	1.19	1.75	2.98	3.44	3.56	2.61	0.67	0.00
B.4	**Kurik Salor**	18,650	Ha																								
	> Rainfall (50% probability)		mm	43.5	74.4	99.8	181.6	137.2	156.4	163	139	112.5	69.2	49.9	26.6	10.9	14.5	13.3	7.7	4.4	3.1	1.1	1.7	2.6	2.5	5.9	10.9
Tersedia	> Avail.water in drain cnls can be utilized for irr. (mm)		mm	32.63	55.80	74.85	136.20	102.90	117.30	122.25	104.25	84.38	51.90	37.43	19.95	8.18	10.88	9.98	5.78	3.30	2.33	0.83	1.28	1.95	1.88	4.43	8.18
	in MCM		MCM	6.08	10.41	13.96	25.40	19.19	21.88	22.80	19.44	15.74	9.68	6.98	3.72	1.52	2.03	1.86	1.08	0.62	0.43	0.15	0.24	0.36	0.35	0.83	1.52
Kebth	> Total water required from the field storage		(m3/s)	3.06	7.94	0.00	4.71	14.28	10.60	4.39	3.89	0.00	5.46	4.35	14.92	14.92	14.92	14.92	13.29	5.37	7.54	12.39	14.34	14.92	11.03	3.40	0.00
	This is based on the assumption that Wreq <0.8 l/s/ha is		MCM	3.97	10.29	0.00	6.10	18.51	13.74	5.69	5.04	0.00	7.08	5.63	19.34	19.34	19.34	19.34	17.22	6.96	9.77	16.06	18.59	19.34	14.29	4.40	0.00
	fulfilled by the field storage																										
Kurang	> Additional water required (MCM)		MCM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.62	17.81	17.31	17.48	16.15	6.34	9.33	15.90	18.35	18.97	13.94	3.58	0.00
	(water provided by the primary cnl, by gravity flows)		m3/s	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.05	13.74	13.36	13.48	12.46	4.90	7.20	12.27	14.16	14.64	10.76	2.76	0.00

Can be concluded from **Table 3-19 to Table 3-24** that the water availability of the conservation /drainage canals without inflow from the river or from the suppletion canal cannot support the demand. A direct connection from the conservation /drainage canals to the secondary canals has been designed.

3.4.6.4 Lower Jagebob irrigation scheme

DI Lower Jagebob consists of 3 sub schemes namely DI Jagebob Raya, DI Kamnosari and DI Mimi Baru. Based on the hydro topographic map, this Lower Jagebob area is not a lowland area, but an upland area as shown in **Figure 3-19**, Lower Jagebob Hydro topography Map below. In this case tidal irrigation is not possible in this area.

Figure 3-19 Hydro-topographic map of Lower Jagebob



There is no water source that allows for gravity irrigation water supplementation because this area is at an elevation of 12-17 m above MSL. Therefore, it is necessary to pump from the Maro river.

The pumping system here is only an addition, while the provision of water still relies on rainfall and water collected in the channel, both the suction channel, the drain channel and the existing long storage.

Additional supply from the pump is only needed at certain times, namely in the second half of the 2nd growing season and during the dry season.

Table 3-25 Water supply to the area of Mimi Baru

Water supply to the area of MIMI BARU

Item			Des	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
			31	31	28	31	30	31	30	31	31	3	31	30
Water requirements		(l /s/ha)	0.08	0.13	0.74	0.30	0.02	0.55	1.27	0.97	0.35	0.66	0.80	0.18
		(m3/s/1000ha)												
Net water reqirements supplied by the field storage														
Field capability			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sisa hujan yang terkumpul dri sal drain dan suply (mm/day)		50%*R_{50}	1.45	3.33	4.90	5.43	3.75	1.66	0.36	0.44	0.15	0.04	0.09	0.20
Dapat dimanfaatkan 75%		75%	1.09	2.50	3.68	4.08	2.81	1.25	0.27	0.33	0.11	0.03	0.07	0.15
		l/sec/ha	0.13	0.39	0.57	0.63	0.43	0.19	0.04	0.05	0.02	0.00	0.01	0.02
Net water reqirements from field		l/sec/ha	0.63	0.89	1.07	1.13	0.93	0.69	0.54	0.55	0.52	0.50	0.51	0.52
Net water reqirements from suply canal		l/sec/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.42	0.00	0.16	0.29	0.00
Water requirements for each scheme:	Area (Ha)	(m3/sec)												
Total field requirements	1,147.00		***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.836***	***0.477***	***0.000***	***0.184***	***0.337***	***0.000***
Total water req. from field storaga and canals		(m3/s)	0.000	0.000	0.000	0.000	0.000	0.000	0.836	0.477	0.000	0.184	0.337	0.000
		MCM	0.000	0.000	0.000	0.000	0.000	0.000	1.083	0.618	0.000	0.238	0.437	0.000
Max water requirement	0.836	(m3/s)												

Table 3-26 Water supply to the area of Jagebob Raya

Water supply to the area of JAGEBOB RAYA

I t e m			Des	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
			31	31	28	31	30	31	30	31	31	3	31	30
Water requirements		(l /s/ha)	0.08	0.13	0.74	0.30	0.02	0.55	1.27	0.97	0.35	0.66	0.80	0.18
		(m3/s/1000ha)												
Net water reqirements supplied by the field storage														
Field capability			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sisa hujan yang terkumpul dri sal drain dan suply (mm/day)		$50\%*R_{50}$	1.45	3.33	4.90	5.43	3.75	1.66	0.36	0.44	0.15	0.04	0.09	0.20
Dapat dimanfaatkan 75%		75%	1.09	2.50	3.68	4.08	2.81	1.25	0.27	0.33	0.11	0.03	0.07	0.15
		l/sec/ha	0.13	0.39	0.57	0.63	0.43	0.19	0.04	0.05	0.02	0.00	0.01	0.02
Net water reqirements from field		l/sec/ha	0.63	0.89	1.07	1.13	0.93	0.69	0.54	0.55	0.52	0.50	0.51	0.52
Net water reqirements from suply canal		l/sec/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.42	0.00	0.16	0.29	0.00
Water requirements for each scheme:	Area (Ha)	(m3/sec)												
Total field requirements	2,195.00		***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***1.599***	***0.912***	***0.000***	***0.351***	***0.646***	***0.000***
Total water req. from field storaga and canals		(m3/s)	0.000	0.000	0.000	0.000	0.000	0.000	1.599	0.912	0.000	0.351	0.646	0.000
		MCM	0.000	0.000	0.000	0.000	0.000	0.000	4.146	2.443	0.000	0.091	1.729	0.000
Max water requirement	1.599	(m3/s)												

Table 3-27 Water supply to the area of Kamnosari

Water supply to the area of KAMNOSARI

I t e m			Des	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
			31	31	28	31	30	31	30	31	31	3	31	30
Water requirements		(l /s/ha)	0.08	0.13	0.74	0.30	0.02	0.55	1.27	0.97	0.35	0.66	0.80	0.18
		(m3/s/1000ha)												
Net water reqirements supplied by the field storage														
Field capability			0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Sisa hujan yang terkumpul dri sal drain dan suply (mm/day)		50%*R_{50}	1.45	3.33	4.90	5.43	3.75	1.66	0.36	0.44	0.15	0.04	0.09	0.20
Dapat dimanfaatkan 75%		75%	1.09	2.50	3.68	4.08	2.81	1.25	0.27	0.33	0.11	0.03	0.07	0.15
		l/sec/ha	0.13	0.39	0.57	0.63	0.43	0.19	0.04	0.05	0.02	0.00	0.01	0.02
Net water reqirements from field		l/sec/ha	0.53	0.79	0.97	1.03	0.83	0.59	0.44	0.45	0.42	0.40	0.41	0.42
Net water reqirements from suply canal		l/sec/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.52	0.00	0.26	0.39	0.00
Water requirements for each scheme:	Area (Ha)	(m3/sec)												
Total field requirements	1,611.00		***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***1.335***	***0.831***	***0.000***	***0.419***	***0.635***	***0.000***
Total water req. from field storaga and canals		(m3/s)	0.000	0.000	0.000	0.000	0.000	0.000	1.335	0.831	0.000	0.419	0.635	0.000
		MCM	0.000	0.000	0.000	0.000	0.000	0.000	1.730	1.076	0.000	0.543	0.823	0.000
Max water requirement	1.335	(m3/s)												

3.4.6.5 Kuprik Sidomulyo lowland irrigation scheme

Kuprik Sidomulyo is in the lower reaches of the Maro River. Hydro topographically, this area belongs to category C (**Figure 3-20**).

Figure 3-20 Hydro-topographic map of Kuprik Sidomulyo

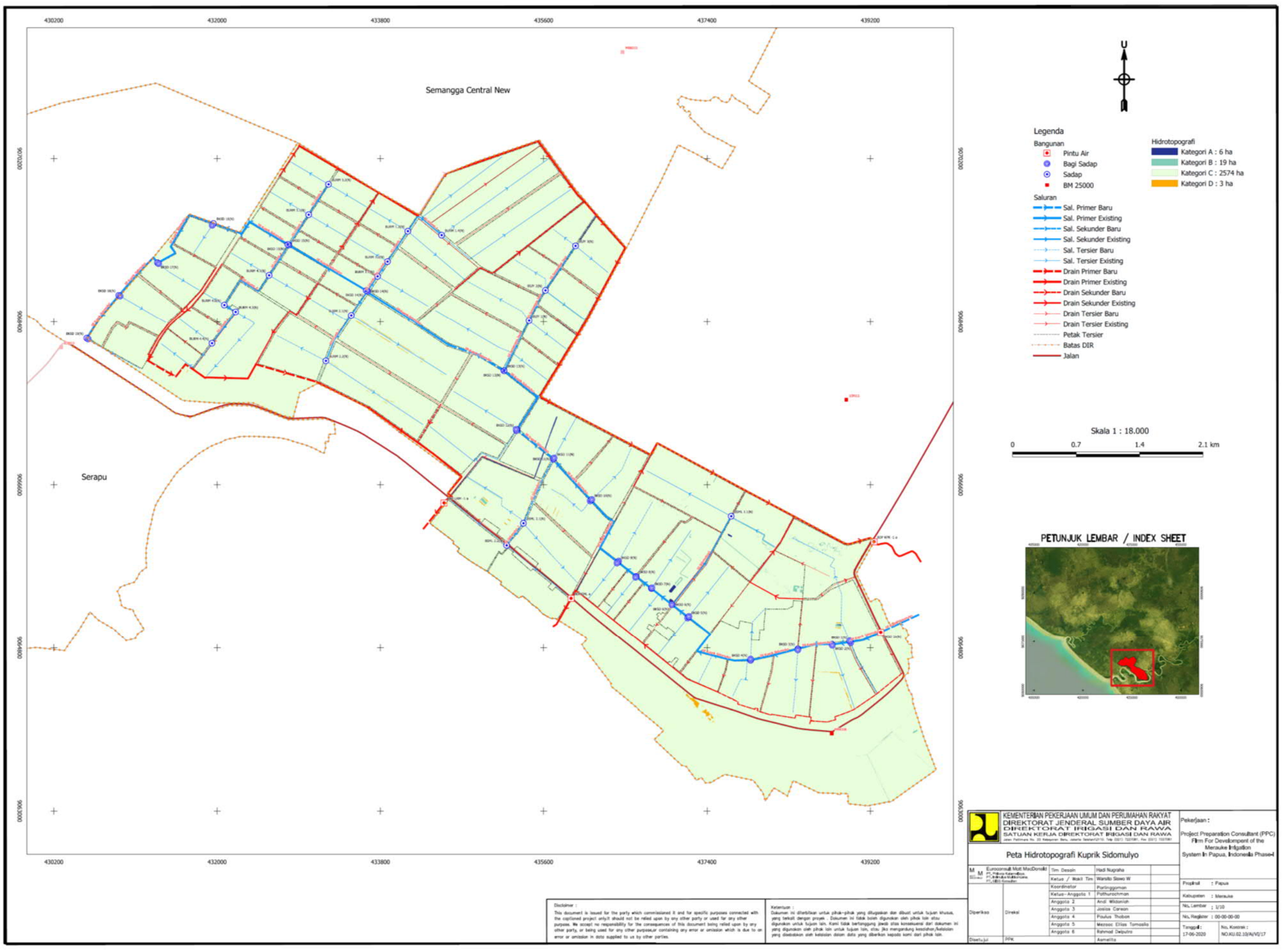


Table 3-28 Water supply to the area of Kuprik Sidomulyo

Water supply to the area of KUPRIK SIDOMULYO

I t e m			Des	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
			31	31	28	31	30	31	30	31	31	3	31	30
Water requirements		(l /s/ha)	0.08	0.13	0.74	0.30	0.02	0.55	1.27	0.97	0.35	0.66	0.80	0.18
		(m3/s/1000ha)												
Net water reqirements supplied by the field storage		l/sec/ha												
Field capability			0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Sisa hujan yang terkumpul dri sal drain dan suply (mm/day)		50%*R_{50}	1.45	3.33	4.90	5.43	3.75	1.66	0.36	0.44	0.15	0.04	0.09	0.20
Dapat dimanfaatkan 75%		75%	1.09	2.50	3.68	4.08	2.81	1.25	0.27	0.33	0.11	0.03	0.07	0.15
		l/sec/ha	0.13	0.39	0.57	0.63	0.43	0.19	0.04	0.05	0.02	0.00	0.01	0.02
Net water reqirements from field		l/sec/ha	0.63	0.89	1.07	1.13	0.93	0.69	0.54	0.55	0.52	0.50	0.51	0.52
Net water reqirements from suply canal		l/sec/ha	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.42	0.00	0.16	0.29	0.00
Water requirements for each scheme:	Area (Ha)	(m3/sec)												
Total field requirements	1,943.00		***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***0.000***	***1.416***	***0.807***	***0.000***	***0.311***	***0.572***	***0.000***
	Max													
Total water req. from suply canals		(m3/s)	0.000	0.000	0.000	0.000	0.000	0.000	1.416	0.807	0.000	0.311	0.572	0.000
		MCM	0.000	0.000	0.000	0.000	0.000	0.000	3.670	2.093	0.000	0.806	1.481	0.000
Max diversion	**1.416**	(m3/s)												

3.4.6.6 Tanah Miring lowland irrigation scheme

The land elevation of Tanah Miring SP9 is mostly at 2.0 – 3.5 m, there is a small high land at the northeast part of the scheme with an elevation of 4.0 – 7.0 m. With spring tide river water level about 2.0 m, most of the land is not overflowed by the tide water, that means manly under the hydro topographic categories C and D. In the rainy season most of the water is from rainfall. Some water can be obtained from the Kumbe river tide. Tidal water from Kumbe river enters through the flap gate structure into the primary canals. Furthermore, water is pumped from the primary canal to the paddy fields, either directly to the collector canals or through the secondary canals. It is predicted that the pumps will only be operated in the daytime. Some people start at 8 am gradually increasing to full capacity at 9. Some people stop pumping start at 16 pm and gradually until they all stop at 17 or pumping time about 8 hours a day. There is no other source of irrigation water, neither from swamps nor natural drainage channels.

Figure 3-21 Hydro topographic map of Tanah miring SP9

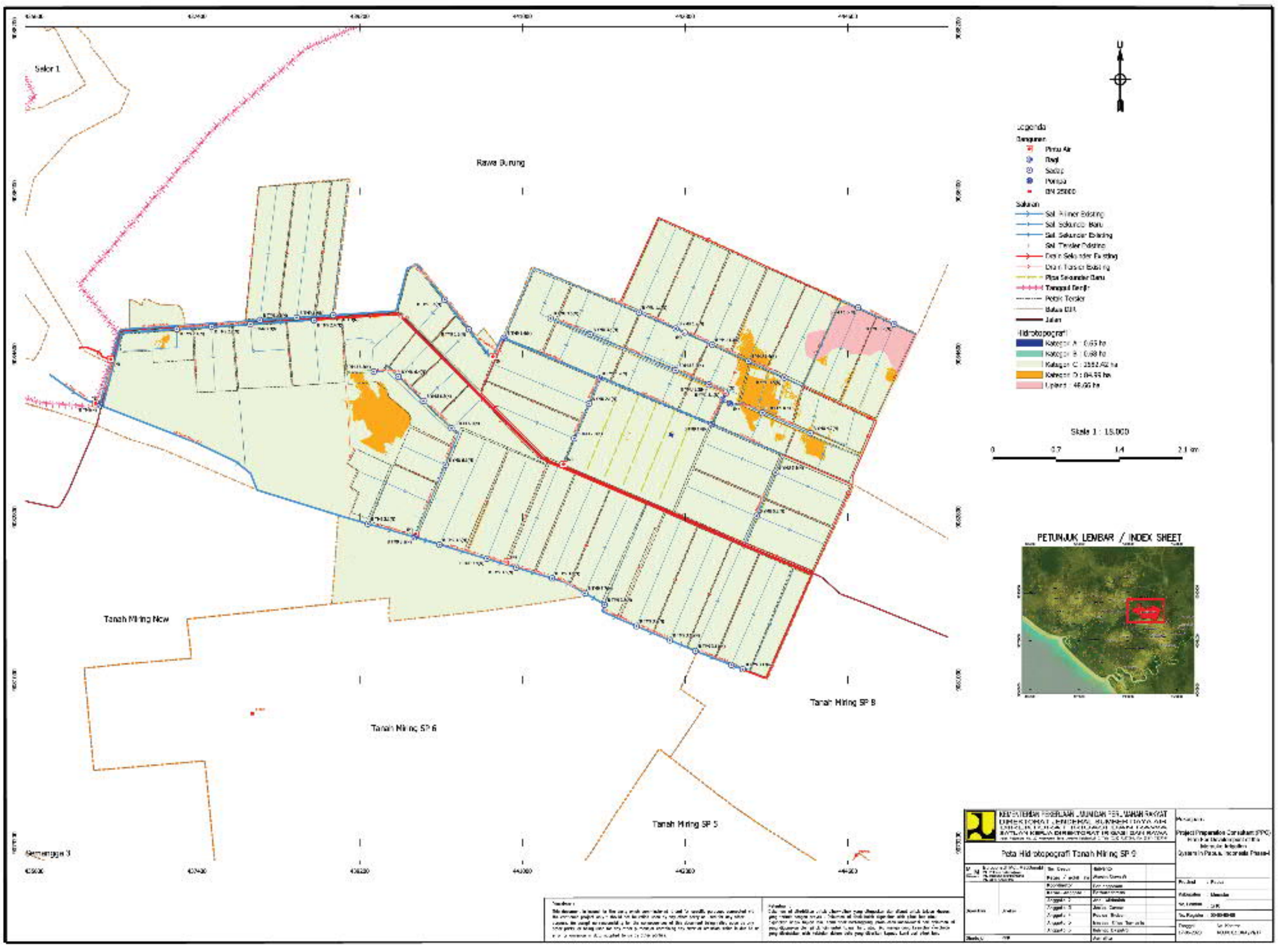


Table 3-29 shows that the volume of water demand for irrigation for one day or one daily cycle of tide is less than the volume of water retained in the primary canals at the mean river water elevation. That means the water in primary canals is enough to serve irrigation until the next tidal water comes in.

Table 3-29 Water supply to Tanah Miring schemes

Item			Des	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Water requirements		(l/s/ha)	0.82	0.19	0.76	0.43	0.61	0.66	1.12	0.99	0.31	0.66	0.61	0.14
	Net Area (Ha)													
Tanah Miring SP2	**658.00**	(m3/sec)	0.539	0.127	0.497	0.284	0.404	0.434	0.735	0.652	0.203	0.437	0.405	0.092
		(10^3 m3/day)	46.61	10.98	42.97	24.51	34.91	37.54	**63.47**	56.31	17.57	37.76	34.96	7.92
Tanah Miring SP4	833.00	(m3/sec)	0.683	0.161	0.630	0.359	0.512	0.550	0.930	0.825	0.257	0.553	0.512	0.116
Tanah Miring SP7	926.00	(m3/sec)	0.759	0.179	0.700	0.399	0.569	0.611	1.034	0.917	0.286	0.615	0.569	0.129
Tanah Miring SP4 + SP7	**1,759.00**	(m3/sec)	1.442	0.340	1.330	0.758	1.080	1.161	1.964	1.742	0.544	1.168	1.082	0.245
		(10^3 m3/day)	124.59	29.35	114.88	65.51	93.34	100.34	**169.67**	150.54	46.97	100.95	93.46	21.17
Tanah Miring SP 9	**1,662.35**	(m3/sec)	1.363	0.321	1.257	0.717	1.021	1.098	1.856	1.647	0.514	1.104	1.022	0.232
		(10^3 m3/day)	117.74	27.74	108.57	61.91	88.21	94.83	**160.35**	142.27	44.39	95.41	88.32	20.00
Volume of Primary Canals at river normal water level						Maximum daily water demand								
		(x 103 m3/day)							($x 10^3$ m3/day)					
Tanah Miring SP2		**121.5**							**63.5**					
Tanah Miring SP4 + SP7		**213.6**							**169.7**					
Tanah Miring SP 9		**252.4**							**160.4**					

A HEC-RAS Model was done which calculated the water balance in the primary canal with the following assumptions: a) the dimensions of the primary canals are the same with the DED calculations; b) the water demand for the rice fields is the largest during second paddy crops (MT2), that is the beginning of land preparation; c) the model period is 15 days or one tidal cycle, this is including the neap and spring tides; d) it is assumed that there will be no additional rainwater during the cycle period; e) the intake structure is equipped with flap gates to let the river water enter into the primary canals; f) drainage structure is equipped with a spill structure as high as the normal mean river water level to prevent some of the tidal water flowing back into the river up to the river mean water level. The result of the model is that during no rainfall days, without any rainwater at the second planting season, the water demand will be fulfilled by the river water. It is clear that the above calculation is based on the maximum requirement for rice and without any additional rainwater, this means that all other smaller value of water requirements can be fulfilled by the tide river water.

At the end of dry season or during a longer dry season period the river water becomes saline. When the salinity is more than 4,000 ppm, the water is not suitable for irrigation, it will reduce the paddy production. When tidal river water comes from downstream the salinity is higher, the control gates must be closed to prevent saline water from river entering the primary canals. When the tide moves down, river water comes from upstream, the salinity decreases, some river water can be entered and will be diluted by the drainage water in the canals.

The conditions of Tanah Miring SP2, SP4, and SP7 are similar as Tanah Miring SP9. The land elevation is about 2.0-3.5 m, and there is a small higher elevation area in SP2 with an elevation of 4.0-5.0 m. This means that most of it is not overflowed by tidal water from the river. The hydro topographic categories are C and D. In the rainy season this network gets water from rainfall. When there is no rain in the dry season or during a few days in the rainy season, water is pumped from the primary canals. The water in the primary canals come from high tide of Maro river. There are no other sources of irrigation water, for example from swamps or natural drainage channels.

Figure 3-22 Hydro-topographic map of Tanah Miring SP2

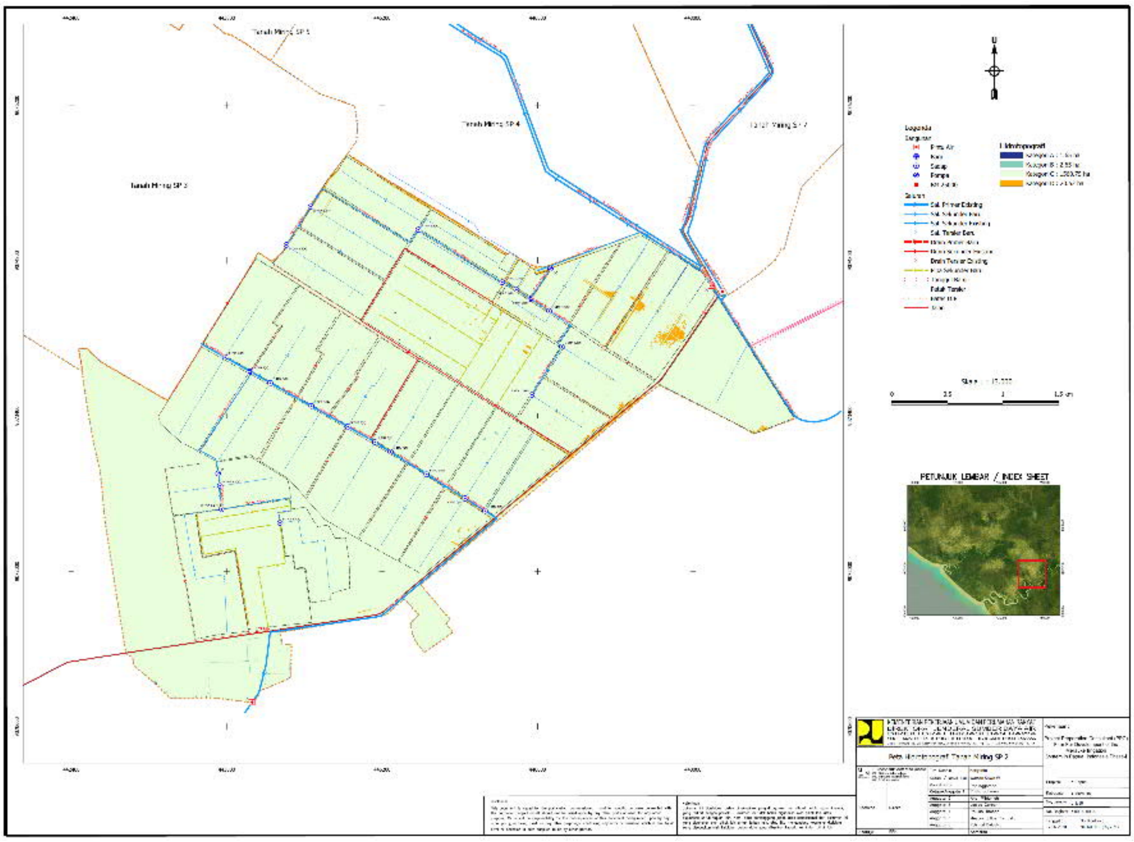


Figure 3-23 Hydro-topographic map of Tanah Miring SP4

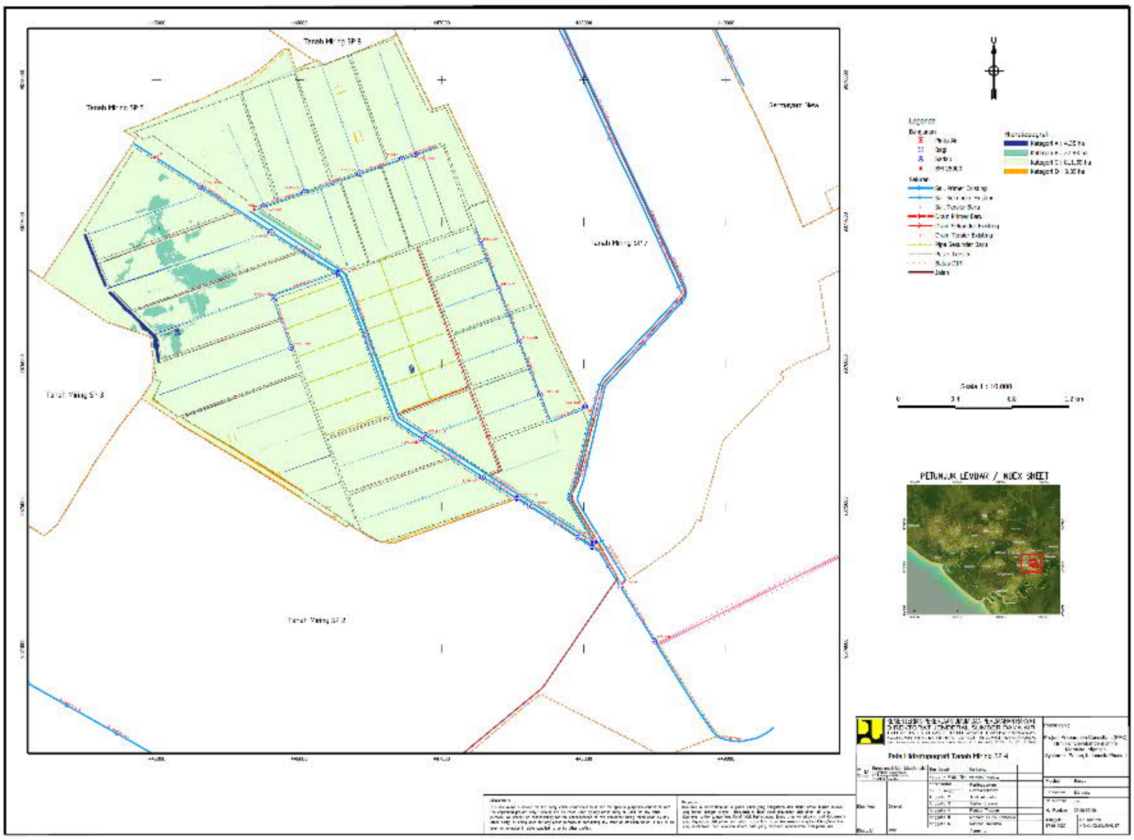
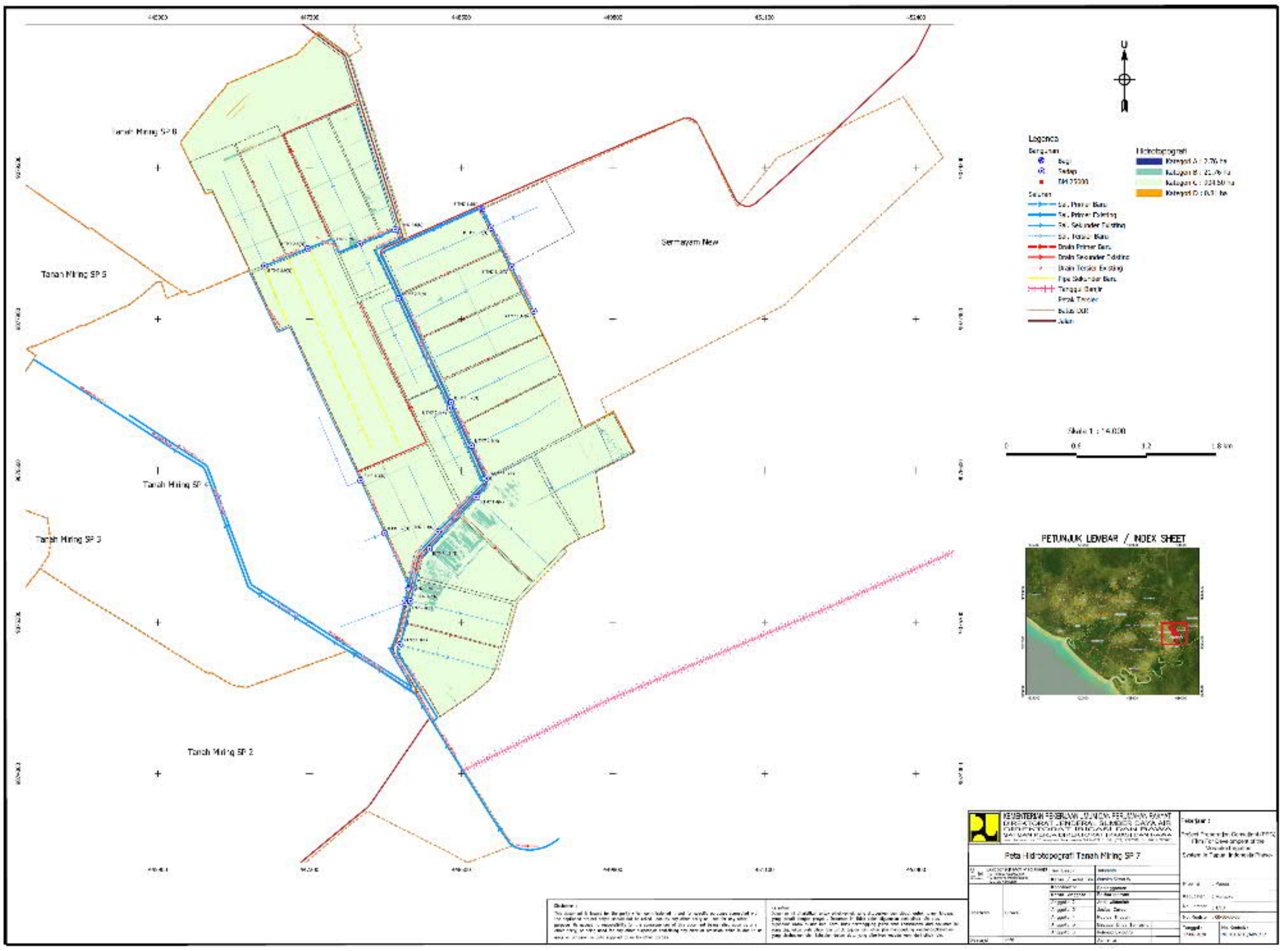


Figure 3-24 Hydro-topographic map of Tanah Miring SP7



A HEC-RAS model was done for the Tanah Miring SP2. SP4, and SP7, with pumping conditions, flap gate structures, and drainage spill structure like the Tanah Miring SP9 mentioned above. In this case, only the tidal fluctuations of Maro river differ from those of Kumbe river. The result of this model is also similar, that without any rainwater, for the rice second planting season the water requirements are met with water from river tides.

3.5 Irrigation plan and layout

3.5.1 General

Based on the development phases (of Phase 1 and 2) the total development would be 51,100 Ha. The detail of the development is presented in **Table 3-30.**The area is distributed over several irrigation scheme blocks, namely: Kurik, Salor, Jagebob, Sermayam, Tanah Miring, Semangga, and Kuprik & Serapu.

Table 3-30 Proposed irrigation development area for Phase 1 and 2

Phase 1: 2022-2026		MCA Rank	Area (ha)
A	**Central govt. schemes**		
1	Kurik 2	9	2,059
2	Kurik 5 and 6	7	2,820
3	Kurik 1	10	2,311
4	Tanah Miring 2,4,7	6	2,295
5	Tanah Miring 9	8	1,890
6	Lower Jagebob	3	4,580
		Subtotal	**15,956**
B	**Provincial/Kabupaten schemes**		
7	Salor 1,2,3,4	1	4,547
8	Kuprik-Sidomulyo	5	1,944
9	Kumbe Kampung		477
		Subtotal	**6,967**
C	**New schemes**		
10	Semayam New	18	1,339
11	Salor Kampung	18	621
12	Kumbe homeyards PMI		167
13	Maro homeyards PMI		73
		Subtotal	**2,200**
		Total phase 1	**25,122**

Phase 2: 2027-2031		MCA Rank	Area (ha)
A	**Central govt. schemes**		
1	Kurik 3,4	6	4,905
2	Erom PS1	2	1,672
3	Middle Jagebob, various	4	2,363
4	Semangga 1,2	2	3,255
5	Tanah Miring 3,5 (Maro)	2	1,771
6	Tanah Miring 6 (Kumbe)	2	1,878
		Subtotal	**15,844**
B	**Provincial/Kabupaten schemes**		
4	Serapu	11	3,118
		Subtotal	**3,118**
C	**New schemes**		
5	Semangga Central New	16	2,705
6	Salor New	15	1,166
7	Kumbe homeyards PMI		2,128
8	Maro homeyards PMI		1,043
		Subtotal	**7,042**
		Total phase 2	**26,003**

3.5.2 Water requirements

From the hydrology and agriculture analysis, the water requirements at the field is 0.95 l/s/ha for inundated rice, at the collector levels it is 1.12 l/s/ha (efficiency 80%). The water requirements at each collector then summed according to their position in the system. And so, for secondary canals have been treated the same, and the result of water requirements at the secondary should be multiplied by the efficiency factor. The water requirements as secondary canals and primary canals are 1.32 l/s/ha and 1.46 l/s/ha consecutively.

For palawija crops the peak field requirement is 0.70 l/s/ha, at tertiary level 0.78 l/s/ha, at secondary level 0.86 l/s/ha and at primary level 0.96 l/s/ha. The fact that young dryland crops need far less water than rice, as this depends on their limited root zone volume as well as reliable rainfall being more effective, means that dryland irrigated crops require only 25% the water requirements for rice. Consequently, growing such crops on the higher pumped areas is far more economic in terms of pipeline sized costs and pumping operational costs.

The information on the water requirement in the system is presented in Irrigation system schematic diagram (in Appendix B).

3.5.3 Proposed design layout

The lay out of the lowland irrigation system is determined by several aspects: topography /hydro topography of the development area, the land suitability, incorporation of the existing lowland irrigation systems, and the source and quality of the water. The layout should also consider the aspects of operation and maintenance which includes the accessibility throughout the system by the condition of the inspection and maintenance roads.

The new development layout for each scheme is presented in **Appendix G Layouts and Schematic Diagrams.**

Descriptions of the canals in the layout are:

(1) Suppletion canal: a canal that leads from the intake to the division structure at where the flow divided into primary canals.
(2) Primary lowland irrigation network is part of the lowland irrigation network consisting of main/primary canals, and related structures such as: subdivision, bridges, culverts, cross drainage, flumes, structures for tapping, and complementary structures.
(3) The secondary lowland irrigation network is part of the lowland irrigation network consisting of secondary canals, pump stations, division structures, offtake tapping structure into collector networks as the service delivery point with the WUAs, and complementary gated control structures.
(4) Collector irrigation network is an irrigation network that is managed by the WUAs and functions as infrastructure irrigation water services in collector plots consisting of collector channels, quaternary canals and drains, collector boxes, quarter boxes, and complementary buildings as WUA offices.
(5) Drainage /conservation canal in the lowland irrigation network is part of the lowland irrigation network consisting of drainage /conservation canals, canal combining, and complementary gated outlet structures.

3.5.4 Nomenclature

As the designed system is quite different with the existing, the nomenclature should be adjusted accordingly.

3.5.5 Canal layout design

- ***Topographic mapping***

  The topographic mapping provides the detailed up to date existing field conditions of the whole scheme especially when combined by imagery from orthophoto mapping or rectified satellite imagery. The designer can see canal and drain alignments and widths, tracks and roads, structures, field boundaries and buildings. Using those maps canal routing can be designed although in most cases they will follow existing canal alignments. When orientating the canal route, topographic and hydro-topographic condition should also be considered so that canals tend to pass from high areas to lower areas. Following the initial canal routing, an overall recheck should be carried out to ensure the proposed system optimises the topography to minimise the cut and fill balance.

- ***Canal route consideration***

  There are three choices of water provision to the field. The first is to provide irrigation water from the supply system, and the second is to provide water from the drainage /conservation canals.

  For the first case, canal route is designed from the field to the water source to ensure the whole area is commanded as well as having sufficient storage between tidal peaks. It is unavoidable to lift water from the primary canals to the secondary canals in order to command the whole area as the relative slope of the land is very small, and mostly above river and tidal levels. Following pumping at the start of secondary canals, the water can flow by gravity to the collector canals through the offtakes.

  In the second case that field water supply comes from the drainage /conservation canals (drainage cum storage). The drainage canals should be able to provide water to the area, although the water level is lower than the field. Water will be lifted by small pumps to the tertiaries and hence flow to the field.

  The third case is about providing irrigation water from the conservation system. All rainfall water will be kept as far as possible in conservation systems in the form of retention ponds and canals. From there, water is transferred into the canal system and raised to the field by pumps.

  A single scheme can have these three choices (for example: Kurik and Salor), or just the second choice (for example: Semangga or Tanah Miring), or the third choice (for example: Middle Jagebob which will depend on swamp storage).

- **Problems**

  The existing land slope is very low; therefore it requires a large canal size to transmit a reliable discharge. As a consequence, the flow velocity will be low, something un-avoidable especially when the canals are also designed to hold inter-tidal storage. The second problem is about the salinity of water in the river. During some certain period of time, water in the river will be influenced by salinity from the sea. Due to this condition, water inflow to the drainage /conservation canals should be stopped using the stoplogs at the outlet structures and the gates on the intake structures. It means that farmers only rely on the stored water in the drainage /conservation canals if there is no other irrigation water sources available.

  It should also be noted that pilot areas are proposed for farmers in high salinity areas to learn to adapt to increasing salinity due to climate change. Such strategies include using saline tolerant crops, including rice, scavenger wells for groundwater use, hydrophyte algae that reduce salinity and seawater greenhouses.

- ***Canal operation and regulation considerations***

  Canals are designed for a specific capacity and functions. For supply canals, it is determined by the maximum irrigation requirements. It is necessary to maintain the water level by means of ‘a check’ in such that will allow water to flow through the offtakes.

  For drainage /conservation canals which has a double function: to drain the excessive water and to keep water levels (and volume) so it can be used as water for crops, the water level should be maintained not too high, but its volume still enough to serve water to the field when needed. A control structure is needed at the connection with the open water (river). The control structure has function to flow water out during the wet seasons, and to retain drainage water during the dry season whilst preventing saline water entering.

  In designing these schemes there are opportunities to connect the drainage canals with the primary supply canals. Water will then always be available for farmers to irrigate their land. A control structure has a function regulate the flow and to a certain extent measure it should that be required.

- ***Canal flow measurements***

  This effort to install canal flow measurement basically directing to achieve semi-technical irrigation system. Flow measurements are very essential to measure the flow discharges entering the suppletion canals, the primary canals and the secondary canals. When it is needed, a flow measurement can also be attached at the mid length of secondary as it is useful to measure the rate of losses.

  In managing an irrigation scheme as a service providing organisation, at fully technical level the key interface to measure is that between the operator and the clients (in this case the WUAs). At present it is clear that the irrigation management organisation is under-funded and under staffed to carry out this function. As offtakes will have control gates or hand stops, they should be complemented with a downstream broad crested weir as this can be provided in most cases by just 0.06 m3 of mass concrete. This will be in preparation for when greater priority is given to irrigation management.

  It is noted that the flows in the drainage canals difficult to be measured.

3.6 Method of water distribution

3.6.1 General

The method of water distribution will play an important role in determining water management duties and task descriptions. Under normal situations the canal dimensions are sized efficiently to deliver water continuously to the field. However, in the case of these lowland schemes, water is admitted into the canal systems on an intermittent basis depending on tidal variation. Within the transfer from the primary canals to the secondaries it is assumed that pumping will occur over an 8 hour period, although during the highest demands this may be extended to a 12 hour period to maintain capital pump costs. The operators have several options to negotiate with the farmers such as:

a. should the operators maintain pumping with use to provide water that flows to the fields;
b. should the operator pump to an agreed level then the farmers pump from this level to the field;
c. should the operator fill the secondaries and lower order canals on an intermittent basis whilst the farmers spend several days pumping until a minimum level is reached before the secondary canal pumps are restarted.

Within the collector block itself, water can be distributed intermittently or continuously. Where water levels upstream are maintained, it is possible to set rice paddies to flow continuously without tending them overnight. This is more difficult if upstream levels vary when main pumps are turned off. Most farmers, and their families in particular, are reluctant to work at night. During the day the farmers will have to organise more complex pumping and canal tending operations to rotate flows within the restriction of changing water levels. The proposed water management system will dictate the size of the freeboard of the collector canals especially if management option a. above is chosen.

3.6.2 Utilisation of conservation storages and drainage returns

The present irrigation practised by farmers in most of the schemes is intermittent as it is supported by farmers individual pumping. However, pumping supplements rainfall with this being more progressive into the dry season as rainfall becomes less reliable. In the future, when the supply system is available, the irrigation method will, within the dry season, become irrigation augmented by drainage cum storage. During the normal situation when field water demands equal or are close to 0.95 l/s/ha farmers near the coast will obtain greater volumes of their irrigation water from the drainage/conservation canals from upstream areas as the rivers become saline. This situation will become more usual in time as sea levels rise and salinity concentrations penetrate further up the rivers. Irrigation water supply through the supply system will better support the schemes supplied from the higher river reaches such as Kurik and Jagebob. Lower schemes such as Kuprik-Sidomulyo, Kumbe Kampung and the Semangga schemes will benefit from the irrigation returns of Kurik and Tanah Miring. Towards the end of the dry season schemes such as Salor and Tanah Miring can augment and dilute river flows with water stored in retention ponds and old river oxbows.

3.6.3 Rotation in the secondaries and collector canals

The existing canals have been designed and built with storage in mind. One operational system proposed above (b) suggests a system of intermittent pumping where the secondary and collector channels are filled by secondary pumping to full supply or near full supply levels. Normally this would hold sufficient water for several days use by the farmers. However, once it reached a minimum level the secondary pumps would be activated to refill the canals. The frequency of pumping would depend on the storage volume and the farmers demands.

In terms of the farmers activities, they are assumed to work over an 8-12 hour period in pumping from the canals and guiding the flows through their fields on a rotational basis geared to doing so efficiently to release them to carry out other farming activities. The rotation in the collector blocks would in fact be a system of free rotation although it is assumed that the actual scheduling would be equitably arranged through the WUA.

The rotation in the field areas could also be applied when the irrigation is using water from the drainage /conservation canals. This system would be operated at the timing of choice by the farmers and most likely during daylight hours.

3.7 Irrigation management

3.7.1 General

In this context, it is assumed that an irrigation management institution will also be prepared in-line with the proposed irrigation infrastructure improvements and be well funded. The organisation will be equipped with an organizational structure and a complete job description, and the duties of each element of the organization that are well understood as well as appropriate equipment in good working order sufficient and supplies and spare parts.

To obtain good irrigation management, a good, complete and operable irrigation network is also needed. Thus, a good and well-planned maintenance of irrigation networks is needed. The availability of water for irrigation and distribution of water are also carried out according to the plan. So, the calculation of water needs must be accurate, and based on natural conditions and appropriate cropping plans. The flow rate at the source is predictable; flow discharge in the network is well managed as well.

All aspects of the O&M activities and resources mentioned above can be contained within an asset management system (AMS). In the past these were in the form of ledgers before being upgraded to spreadsheets. This is probably the level that needs initially adopting in Merauke. However, a GIS based AMS is currently being rolled out nationwide and will sometime in the near future be adopted in Merauke with a full training program.

3.7.2 Water application during land preparation

The water requirement during land preparation is large, around 1.5 l/s/ha, or 180% of the average of 0.8 l/s/ha. Under these conditions, the availability of water at the source is sometimes insufficient especially if rainfall and hence the cropping pattern delayed. In most cases the peak can be resolved by spreading the land preparation period over a 2 month period.

Several alternatives could be adopted. For the Kurik scheme, for example, where more farmers seek to pre-saturate early any shortage in the irrigation channel can be augmented from the drainage channels although the outlet structures will need careful monitoring to remove stoplogs should a storm occur. If 0.8 l/s/ha could be provided by the supply channel it may be possible just after the end of the wet season for the drainage channel to supply 0.7 l/s/ha. It is assumed that water enters the main and primary canals at the Kurik intake over a 24hour period and will be stored in the canal system overnight. With about 8-10 hours of pumping per day, at least two months of phasing may still be needed. To shorten this period a reduction in the amount of water given for land preparation can be halved. Land preparation is still carried out, with the condition of the land intermittently saturated.

An alternative is to adopt an SRI type of approach of intermittent land wetting throughout the crop cycle. This will ultimately save some 40% of water use as well as reducing methane emissions.

3.7.3 Gate settings

The arrangement of the gate includes (i) the intake gate on the river which functions to enter water into the supply system, (ii) the gate for the division structures of the suppletion canals to the primary canals or from the primary to the secondary canals, and (iii) the control structure of the drainage canals/conservation canals which is often close to the main rivers.

At the river intake, the structure is equipped with one-way flap gates (downstream) and sliding gate(s). Setting the free intake in the river is done in 2 modes:

a) Rainy season mode, where the sliding gate is opened sufficiently to provide any required irrigation although the aperture will come from operator experience as in many cases the upstream levels are affected by tidal variation. During river floods in the river, the gate is fully closed to prevent sediment entry until the flood has sufficiently receded to normal levels or the sediment has mainly cleared. The gate can then be reset to pre-flood levels.

b) Dry season mode, where the slide gate is fully opened to enter water as much as needed unless salinity levels exceed those permitted for the crops in the field and the gate is closed.
c) The flap gate at the intake structure has a function to hold back water in the canal from returning to the river.

At the head of many secondary canals are pump stations with bypasses with flap gates that automatically close when secondary levels are higher than primary. In case of further leakage the culvert inlets can be sealed with stoplogs.

For the division structure: During the normal condition the gate at the division structure has a function to control the flow entering the downstream; the opening should be adjusted according to the flow. For the purpose of the canal maintenance, the gate should be closed totally. In many division structures there are also offtakes to the collector systems that have a sluice control gate. In some schemes they have a small downstream broad crested weir that could measure flows.

The control structure at the Drainage/Conservation Canal: The design of these structures vary with function and drainage capacity. The outlet structures are two culverts with flap gates at the riverward end and two sets of stoplog grooves at the internal end.

During the wet season, the excessive water in the drain system will be automatically released through the riverward flap gates. When river levels are higher than internal drain levels the gates will be closed. Towards the end of the wet season the stoplogs will be progressively raised to start impounding drainage flows.

In the Salor system during the dry season the two culverts are closed by the stoplogs raised to a level that impounds water without causing flooding. In the Kurik system the downstream flap gate is allowed to open to allow the entry of river water unless it becomes too saline in which case the flap gate is closed to prevent escape of drainage water. The river flow enters the drains and cannot flow back to the river unless the flap gate is in off mode.

The function of the slide gate is to stop flow totally either from canal to the river, or from the river entering the canal.

3.7.4 Maintenance Period

Before the beginning of cropping season in October-November, the canal network should be made ready for maintenance operations. The maintenance period would take about a month to ensure the system is ready, including the gates, pumps, inspection roads, as well as the equipment. In the maintenance period, all canals should be closed, inspected and maintained properly by reforming the canal profiles, sealing leaks, repairing and regrading inspection roads and repairing, desilting and debris removing at structures.

3.7.5 Irrigation efficiencies

For any irrigation system, it is unavoidable that some of the water would be lost for various reasons before reaching the field. Principal losses are caused by evaporation from soil surfaces, evapotranspiration from the plants in the canal, percolation, seepage, and inefficient operations. To make sure that the designed water volume can reach the field, some efficiencies are adopted with guidance from KP-03.

In the existing situation of a *sederhana* scheme the overall efficiency has been taken as 50%[4].

The diversion efficiency is the percentage of flow that can be taken from the river; some flow will be lost. There are three levels of efficiency, which for rice are:

[4] Energy Reduction through Improved Irrigation Practices, JR. Gilley, DG. Watts, in Agriculture and Energy, 1977: Generally, the efficiency of surface irrigation systems varies between 30% and 70%. Average 50%.

- Distribution efficiency: This is for figuring losses from the offtake to the field: about 80%
- Conveyance efficiency: figuring the losses along the secondary and primary canals, about 0.91% where main and primary canals are quite short.
- Diversion efficiency: this used to be 90% as some water would escape past the intake.
- The overall efficiency is 65%.

Note that the field percolation losses are incorporated into the NFR which in the case of inundated rice can be considerable whilst for intermittently irrigated dryland crops the aim is to fill the root zone with only small losses for percolation and evaporation from the soil surface.

For palawija crops the efficiencies are also 80%, 91% and 90% giving an overall value of 0.65.

3.8 Calculation of irrigation water requirements

3.8.1 General

The irrigation water requirement is the volume of water needed to meet the needs of evaporation, water loss, water needs for plants by considering the amount of rainfall and the contribution of ground water (Sosrodarsono and Takeda, 2003).

The water requirement in paddy fields for rice is determined by the following factors:

1. Land Preparation
2. Consumptive Evapotranspiration
3. Percolation
4. Water Layer Replacement
5. Effective Rainfall

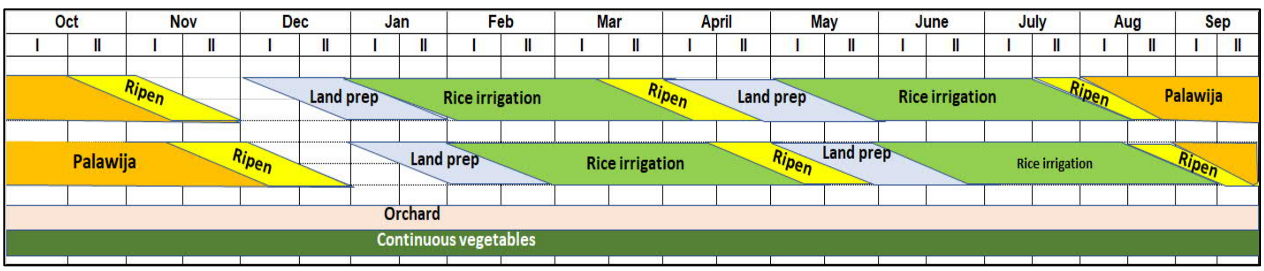
The total water requirement in paddy fields covers factors 1 to 5. The net water requirement in paddy fields (NFR) also consider the effective rainfall. In addition, the efficiency of the primary canal to the collector canal must be considered. The amount of efficiency from the primary canal to the collector canal is 65%.

3.8.2 Cropping pattern

The recommendation cropping patterns in the field are Paddy-Paddy-*Palawija*. The first crop of rice cultivation usually starts at the beginning of December but could be earlier or later depending on rainfall and will be harvested in March or April. The second rice crop usually starts in April with irrigation completed by the end of July or August. In the third crop which is the peak of dry season, it is planned to plant Palawija because palawija doesn’t require as much water as paddy. The third crop will start in August and completed in the end of November.

The proposed cropping pattern is shown on **Figure 3-25** with half of the rice farmers carrying out pre-saturation at the beginning of December and the other half pre-saturating through January, which is the same as a single group carrying out pre-saturation spread over 60 days.

Figure 3-25 Cropping pattern used for calculations.



Rice cultivation starts with land preparation of 1 month where the fields are pre-saturated which is spread over a period of 2 months and are ploughed and harrowed whilst the rice is in a nursery and transplanted after 30 days. Irrigation of the crop follows for 75 days, then a half month for ripening when fields are drained down and no irrigation applied, and harvest takes place at the end of this period.

The paddy-paddy-palawija cropping pattern is recommended for areas where the elevation of the land is not too high/far from water supply such as Kurik, Salor 1 and 3, and Tanah Miring. However, for areas that are quite high, such as Jagebob, Salor 2 and 4 the recommended cropping pattern is paddy-*palawija-palawija*, because the pumping demands are far less: 40% less for the peak half month and 25% over a full season as effective rainfall is more effective. Note that the first rice crop will be supplied mainly from rainfall and pumping would only be used during an unusually dry period. In addition, there are new Irrigation Area (which has not been planted with paddy) that have been proposed from BWS Merauke such as Salor Kampung and Salor New which are recommended for maize and will adopt the Padi-*Palawija-Palawija* cropping pattern.

Also shown in **Figure 3-25** is an initiative to introduce on a pilot basis pumped micro irrigation into community settlement areas to grow high value and nutritious crops such as fruit and nut trees and vegetables. Should these pilots be successful in both transmigration and OAP communities they will be rolled out during Phase 2 to all the communities within the FS area. Some of the new schemes, currently cleared but not cultivated, could be Usaha II land for transmigration and OAP communities to develop HV crops.

3.8.3 Water requirements

The paddy water requirement in the fields is expressed in mm/day or l/s/ha and can be calculated by the following formula:

$$NFR = Eo + P + WLR - Re$$

Where:

NFR = Net Field Requirement (mm/day)

LP = Land Preparation (mm/day)

Etc = Consumptive Evapotranspiration (mm/day)

P = Percolation (mm/day)

WLR = Water Layer Replacement (mm/day)

Re = Effective Rainfall (mm/day)

Water is needed during the land preparation phase to prepare the soil and soil moisture for plant growth. During land preparation fields are progressively pre-saturated, ploughed and harrowed whilst at the same time those pre-saturated are maintained at the same water depth. This is best simulated by the Zijlstra - Van de Goor equation which provides pre-saturation and maintenance water (M), the duty in mm/day over spread time (T). It simulates a wetting front that slows as more fields are pre-saturated and more of the flow is required for maintenance water. The formula can be seen below:

$$LP = \frac{Me^k}{e^k - 1}$$ [5]

Where:

LP = Land Preparation (mm/day)

M = Water requirement to replace/compensate for water loss due to evaporation and percolation in saturated rice fields M = Eo + P (mm/day)

[5] Standart Perencanaan Irigasi- KP-01 Perencanaan Jaringan Irigasi

Eo = 1,1 x ETo (mm/day)

P = Percolation

e = Euler's number, a mathematical constant approximately equal to 2.71828 that is the base of the natural logarithms.

k = MT/S

T = Land preparation period (day)

S = Water needed for soil puddling and initial water layer establishment (mm)

In theory both P and S should be determined by field trials in established rice fields.

Important factors that determine the time period for land preparation is:

- Availability of labour and hand tractors or tractors to work the land. In the past traction has been provided by buffalo and cattle but this is becoming increasingly rare especially in Merauke where tractors can also be used for pumping water.
- It is necessary to shorten the period of time so that there is sufficient time for planting paddy for second crop rice. This may be countered by the need to keep young rice plants longer in the nursery to protect them from golden snails (*keong emas*).

These factors are interrelated. Socio-cultural conditions in the rice cultivation area will affect the land preparation time. In addition, the pattern of rainfall also determines the beginning of the land preparation period. In Merauke, land preparation for the first paddy crop begins in December or January, because at these months are the beginning of the rainy season. For the second paddy crops, it usually begins in April or May and it the pre-saturation is spread over 60 days.

Apart from land preparation, percolation is also an important factor in calculating the water requirement value. The percolation rate is very depended on soil properties, for water requirement calculations a percolation value of 3 mm/day has been used.

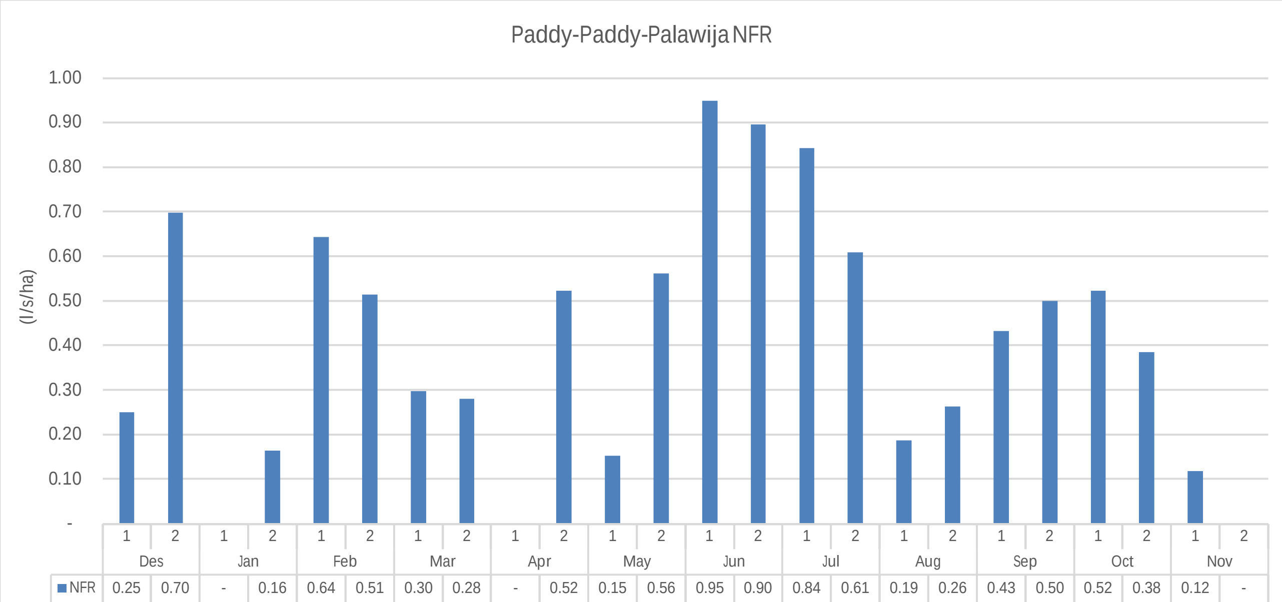
When producing rice, for fertilization and for weeding, the practice of lowering the water level in the fields is used. Based on this treatment the water layer must be replaced. The required layer of water is 50 mm (3.33 mm/day) which is carried out every third and fifth half of the month.

Meanwhile, palawija crops do not need water for land preparation or water layer replacement, so the water requirement for palawija is less than paddy. The *palawija* water requirement is influenced by consumptive evapotranspiration and effective rainfall, it can be seen from the formula below:

$$NFR = Eo - Re$$

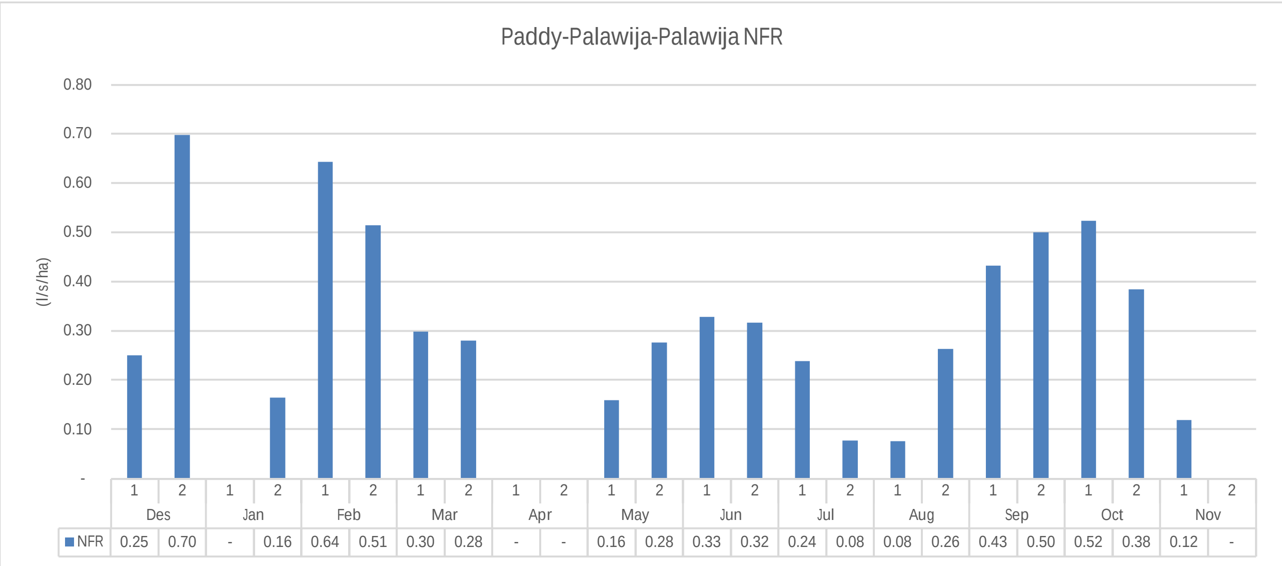
The NFR value obtained from the calculation has units of mm/day which will be converted to l/s/ha by dividing the NFR value by 8.64. The results of these calculations for the paddy-paddy-palawija cropping pattern can be seen in the **Figure 3-26**

Figure 3-26 NFR for paddy-paddy-palawija



Based on graph above, the highest NFR was in the second paddy crop in the first of June with value 0.95 l/s/ha. In the first January first April and the second November, the irrigation requirement is 0, which means in that month the irrigation requirement can be covered from rainfall. The results of the NFR calculation for the paddy-*palawija-palawija* cropping pattern can be at **Figure 3-27.**

Figure 3-27 NFR for paddy-palawija-palawija



The highest NFR value of paddy-*palawija-palawija* cropping pattern occurred during the first paddy planting season, in the second December with value of 0.7 l/s/ha, at this month it was undergoing the land preparation stage. It should be noted that the actual maximum palawija NFR is 0.52 l/s/ha during October.

The NFR value at graphs above represent the net water requirement and does not include the losses from primary to collector canals. The water losses in each channel must be calculated, where the water efficiency in the collector channel is 80%, the secondary channel is 90% and the primary channel is 90%. The total of water efficiency from primary to collector canals is 65% to give the full water demand at the intake.

4 Canals and control structures design

4.1 General

This chapter 4 deals with the canals and structure design criteria and canal sizing. This is related with the previous sub-chapters: 3.5 (Irrigation plan and layout), 3.6 (Method of water distribution), 3.7 (Irrigation management), and 3.8 (Calculation of irrigation requirements).

4.2 Canal design

4.2.1 Canal dimensioning

When the layout of the system has been decided, it should be followed by the water service design and the canal dimension and design. The design follows the guidance given in KP-03 (canals) and KP-4 (structures.. The result of the water service design has been put directly in the design drawing.

Basically, the canal dimension is calculated using the Strickler equation approach:

$$V = K \,.\, R^{(2/3)} \,.\, i^{(1/2)}$$

$$Q = A \,.\, V$$

$$A = (b + mh)\, h$$

$$R = (A / P)$$

$$P = b + 2h\sqrt{1 + m^2}$$

Where:

V : Flow velocity (m/s)

K : Strickler roughness coefficient (K = a number depending on surface roughness. It is the inverse of the Manning equation value n)

R : Hydraulic radius (R = A/P)

I : Flow gradient assumed to be the same as the channel bed during normal depth

A : Cross-sectional area of flow

P : Wetted perimeter

b : Channel bed width

h : Depth of flow

m : The side slope of canal where the slope is 1:m.

Note that on most of the existing canals have been designed with the dual function of both transmitting water and storing it. From a conventional point of view this is an inefficient design but is adapted to the Merauke situation. To minimise cut and fill works the proposed design should adopt the existing widths and side slopes of the existing canals where possible unless a deeper section is required to allow increased entry of tidal flows. The values of b/h are for guidance only.

Parameter values of K, b/h, m and FB used in the canal dimension of the lowland irrigation canals are shown in **Table 4-1.**

Table 4-1 Parameter values of K, b/h, m, and FB

Discharge (m3/s)	Side slope m From KP-3	n = b/h		k Strickler From KP-3	Freeboard (m) From KP-3
		Range	Average		
0.15					
	1	1	1	35	0.4

Discharge (m3/s)	Side slope m From KP-3	n = b/h		k Strickler From KP-3	Freeboard (m) From KP-3
		Range	Average		
0.3					
	1	1.0 - 1.2	1.1	35	0.4
0.5					
	1	1.2 - 1.3	1.25	35	0.5
0.75					
	1	1.3 - 1.5	1.4	35	0.5
1					
	1	1.5 - 1.8	1.65	40	0.5
1.5					
	1.5	1.8 - 2.3	2	40	0.6
3					
	1.5	2.3 - 2.7	2.5	40	0.6
4.5					
	1.5	2.7 - 2.9	2.8	40	0.6
5					
	1.5	2.9 - 3.1	3	42.5	0.75
6					
	1.5	3.1 - 3.5	3.3	42.5	0.75
7.5					
	1.5	3.5 - 3.7	3.6	42.5	0.75
9					
	1.5	3.7 - 3.9	3.8	42.5	0.75
10					
	2	3.9 - 4.2	4	45	1
11					
	2	4.2 - 4.9	4.5	45	1
15					
	2	4.9 - 6.5	5.6	45	1.25
25					
	2	6.5 - 9.0	6.5 - 9.0	45	1.25
40					

4.2.2 Canal side slope

The minimum side slope of the earth canals from KP-3 are:

- Canal depth < 1 m: the minimum side slope 1:1
- Canal depth 1-2 m: the minimum side slope 1: 1.5
- Canal depth > 2 m: the minimum side slope 1:2

For lined canals, the side slope of the canal can be increased to 1: 0.5 for canals with a depth of less than 1.5 m; and 1:1 for canals with a depth of 1.5 – 2.5 m. The minimum thickness of masonry lining is 0.25 m, while for blinding concrete it is at least 8 cm. Recently mesh concrete panels both in-situ and precast have been used where a minimum thickness of 7 cm is recommended. Care should be taken where lined canals pass through areas of high water tables which might dislodge the panels when canal levels are low. In such places small pressure relief flap pipes or weepholes are necessary. Such lined canals will only be proposed for new canals through well-established rice fields or settlements.

4.2.3 Berm and dike

For embankments that have a height of more than 3 m, for every 3 m it is equipped with a berm of at least 1 m. In the case of most existing canals there is an existing track or an easement wide enough for a 3m wide inspection road.

The width of the embankment is determined in accordance with the design discharge, as well as the existence of an inspection road. For canals with a design discharge of 1 m3/sec or less, dikes without inspection roads are 1 m, and dikes with inspection roads are 3 m wide. For canals with a capacity of 1-5 m3/sec, dikes without inspection roads are 1.5 m, and dikes with inspection roads are 5 m wide.

Where possible the inspection road should be along the highest alignment to ensure good drainage. Where possible it should have a course, free draining base that does not rut during the wet season and can be passed at all times by Juru motorcycles. The only heavy vehicles using the road should be maintenance vehicles where the track would be repaired of damage when the work is completed.

Land acquisition limit (ROW) is at least 1 m from the foot of the embankment for the canal above the embankment. For canals in excavations, the land acquisition limit is at least 1 m on the outside of the excavation boundaries.

4.2.4 Longitudinal slope of canals

The longitudinal slope of the lowland irrigation canal in this area with a discharge capacity of 1 m3/sec or less is about 0.0005. For canals with a discharge capacity between 1 - 5 m3/sec, it is around 0.0003 – 0.0004. For canals with a discharge of more than 5 m3/s between 0.0001 - 0.0002. This very low slopes is caused by the topographic condition that is very flat. When similar dimensions of existing canals are inserted into the Strickler equation and the long slope becomes the variable it is even shallower.

The design of the canals has to be carried out in conjunction with an understanding of how they will operate. As many of the schemes have an upstream and downstream boundary condition that is dynamic due to tidal variation, this has been done with HEC RAS transient flow modelling through a series of monthly tidal variations as described in Section 4.6.

4.3 Structure design

4.3.1 Division and offtake structures

a) Division structures:

The function of the division structure is to divide the flow from one main canal or secondary canal to another. This structure is usually equipped with a control gate on the major canal and measurement gate or control gate and downstream measurement structure on the minor canal. The problem with Merauke is that the land is so flat that the head needed for physical measurement is limited without substantially raising canals and, hence incurring costs. On the other hand the control structure will affect levels a long way upstream so that cross regulation structures are not required.

It is proposed that the collector offtake is made in the form of a downflow sliding gate, without being equipped with a flow meter. This is based on considerations of ease of operation. With care and understanding of sluice gate hydraulics, a discharge through the gate can be determined although this will not be very accurate.

The control structure is carefully planned and takes into account the conditions in which the gate is fully opened. The loss of energy should be as small as possible. Where field levels on one branch are much lower than the other, there may be head available for a flow measurement. In this case a flow measurement gate such as a Crump-de-Gruyter could be used.

During an emergency, the gate must be fully closed as soon to avoid damage of the canals downstream. Gates with electric motor drive are more suitable for wide gate span sizes. Gates up to 1.5m width on division structures can be operated manually or electrically. For example, for a gate of 1.5 m wide, it requires 1.5-3 KW electric motor, depending on the depth of flows.

b) Offtake structures:

The offtake structure represents the interface between the scheme operator and the farmers organisation as the client. It is the critical location for measuring the performance of service provision. To the present, measuring flows to ensure they match farmers demands has not been carried out. With so many offtakes and a limited number of field operators and O&M funding this is not surprising. If the intention is to upgrade these schemes to fully technical then a complementary funding and training is required. In the meantime the outlet structures should be provided with broad crested weirs (BCWs) for future use. This would only require a 0.06 m3 volume of concrete to insert it in the channel.

Here, offtakes mean the division from the secondary canals to the collector canal. The structure is arranged with the sliding gate with a downstream BCW. When necessary, a measuring scale can be installed on the upstream side of the weir.

The length of the offtake culvert will depend on whether it is under a 5m or 3m inspection road or just a 1.5m wide embankment and whether this is normal to the road or at an angle. The culvert could be a concrete pipe made of sections, a masonry base and walls with a concrete slab or a box culvert made from 0.10m thick base, walls and top. The latter would be preferred where the ground is soft as well as for being supported by piles.

4.3.2 Canal permissible velocities

Considering the condition of the system, only sub-critical flows will occur. The Froude number of the flow should not exceed 0.5.

$$Fr = \frac{Va}{\sqrt{gA/B}} < 0{,}5$$

Where:

Fr : Froude number,

Va : Average flow velocity in the structure,

A : Area of flow,

B : Width of flow surface

The flow velocity in earth canals should not exceed 2 m/s.

4.3.3 Culverts

Irrigation culverts are sized to have a flow velocity inside of about 0.5 m/s for irrigation. For drainage canals this can be raised. For ease of manufacture, standard round pipe sizes of 0.6 m, 0.8 m, 1 m, 1.2 m or 1.5 m are used. Over 0.60m they should have a layer of mesh culvert through the centre of the wall.

Rectangular culverts can be made in mesh concrete either, in-situ for the full length, or as precast sections say1 m in length.

A study of culvert costs showed that over 1m diameter Armco culvert sections, that nest together in sections for transport, were cheaper than concrete pipes. Generally, they do not need piles for support but should be based on a bed of coarse soils. For Salor 1, Armco culverts of 2m diameter have been proposed in existing deep canals likely to partly fill with sediment.

At pump station bypasses where flap gates are required they have been designed as integral with large HDPE drainage pipes with a stoplog arrangement at the upstream end to ensure sealing once upstream levels are higher. Two pipes have been proposed of different diameters to allow nesting during transport.

4.4 Canal and structure dimensions

4.4.1 General

This chapter describe the collector irrigation services area, the dimension of primary, secondary canals and the drainage canal dimension. The result of the canal design for the whole development schemes are shown in **Table 4-2** to **Table 4-100**. The design drawings are in **Appendix H.**

4.4.2 Collector irrigation services area

4.4.2.1 Collector irrigation services area of Kurik

Kurik 1 Collector irrigation canal parameters

Table 4-2 Kurik 1 Collector irrigation services

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	KLK.5-8ki	17.83	26	RWS.2-4ki	29.49	51	KMB.1-3ka	24.04
2	KLK.5-8ka	21.42	27	RWS.2-4ka	29.78	52	KMB.1-2ka	48.25
3	KLK.5-7ka	26.92	28	RWS.2-3ki	19.10	53	KMB.1-1ki	29.42
4	KLK.5-7ki	32.80	29	RWS.2-3ka	18.98	54	KMB.3-4ka	28.78
5	KLK.5-6ki	24.84	30	RWS.2-2ki	19.45	55	KMB.3-4ki	41.17
6	KLK.5-6ka	24.50	31	RWS.2-2ka	19.59	56	KMB.3-3ka	45.71
7	KLK.5-5ki	11.05	32	RWS.2-1ki	22.58	57	KMB.3-3ki	38.02
8	KLK.5-5ka	10.90	33	RWS.2-1ka	22.22	58	KMB.3-2ka	43.32
9	KLK.5-4ki	24.47	34	RWS.3-5ki	18.49	59	KMB.3-2ki	28.73
10	KLK.5-4ka	24.15	35	RWS.3-5ka	28.52	60	KMB.3-1ka	63.25
11	KLK.5-3ki	24.85	36	RWS.3-4ki	27.33	61	KMB.3-1ki	27.63
12	KLK.5-3ka	24.77	37	RWS.3-4ka	22.67	62	KMB.4-5ki	64.50
13	KLK.5-2ki	23.70	38	RWS.3-3ki	18.16	63	KMB.4-4ka	43.13
14	KLK.5-2ka	23.39	39	RWS.3-3ka	19.29	64	KMB.4-3ki	31.45
15	KLK.5-1ki	26.06	40	RWS.3-2ki	18.82	65	KMB.4-2ka	30.34
16	KLK.5-1ka	41.88	41	RWS.3-2ka	19.42	66	KMB.4-1ka	31.83
17	RWS.1-5ka	24.76	42	RWS.3-1ki	23.39	67	KMB.4-1ki	32.07
18	RWS.1-4ki	41.55	43	RWS.3-1ka	21.83	68	KMB.2-8ki	33.18
19	RWS.1-2ki	26.14	44	RWS.4-2ki	56.00	69	KMB.2-7ki	70.17
20	RWS.1-2ka	32.40	45	RWS.4-1ki	68.00	70	KMB.2-6ki	35.63
21	RWS.1-1ka1	22.44	46	KMB.1-6ka	25.19	71	KMB.2-5ka	44.62
22	RWS.1-1ki	20.94	47	KMB.1-6ki	33.31	72	KMB.2-4ka	31.71
23	RWS.1-1ka2	20.51	48	KMB.1-5ka	42.51	73	KMB.2-3ka2	32.91
24	RWS.2-5ki	19.85	49	KMB.1-5ki	43.49	74	KMB.2-3ka1	64.91
25	RWS.2-5ka	21.26	50	KMB.1-4ka	28.60			

Kurik 2 Collector irrigation services

Table 4-3 Kurik 2 Collector irrigation services

No	Collector Block	Area (ha)	No	Collector Block	Area (ha)	No	Collector Block	Area (ha)
1	KLK.1-6ki	25.49	21	KLK.4-2ka	23.47	41	IVM.1-2ka	92.09
2	KLK.1-6ka	37.54	22	KLK.4-2ki	23.12	42	IVM.1-1ka	77.57
3	KLK.1-5ka	42.49	23	KLK.4-1ka	23.51	43	IVM.2-9ka	43.03
4	KLK.1-4ka	34.82	24	KLK.4-1ki	22.89	44	IVM.2-8ka	28.88
5	KLK.1-3ki	32.29	25	IVM.1-14ka	65.34	45	IVM.2-7ka	23.23
6	KLK.1-3ka	27.62	26	IVM.1-14ki	36.57	46	IVM.2-6ka	9.91
7	KLK.1-2ki	16.62	27	IVM.1-13ka	62.49	47	IVM.2-5ki	36.51
8	KLK.1-2ka	22.82	28	IVM.1-13ki	42.06	48	IVM.2-4ki	46.34
9	KLK.1-1ka	30.22	29	IVM.1-12ka	64.55	49	IVM.2-3ki	19.56
10	KLK.2-3ka	50.71	30	IVM.1-11ki	55.17	50	IVM.2-2ki	21.42
11	KLK.2-2ka	74.12	31	IVM.1-10ka	33.22	51	IVM.2-1ki	12.72
12	KLK.2-1ka	31.25	32	IVM.1-9ka	36.05	52	HMA.4ka	43.65
13	KLK.3-4ka	16.49	33	IVM.1-9ki	37.70	53	HMA.3ka	36.04
14	KLK.3-3ka	21.70	34	IVM.1-8ki	41.92	54	HMA.2ka	47.95
15	KLK.3-2ka	34.21	35	IVM.1-8ka	26.79	55	HMA.1ka	75.13
16	KLK.3-1ka	42.69	36	IVM.1-7ki	19.76			
17	KLK.4-4ka	23.16	37	IVM.1-6ka	107.26			
18	KLK.4-4ki	22.43	38	IVM.1-5ka	110.23			
19	KLK.4-3ka	22.95	39	IVM.1-4ka	78.40			
20	KLK.4-3ki	22.17	40	IVM.1-3ka	36.77			

Salor Kampung Collector irrigation services

Table 4-4 Salor Kampung Collector irrigation services

No	Collector Block	Area (ha)
1	SKG.5Ka	33.11
2	SKG.5Ki	36.98
3	SKG.4Ka	57.70
4	SKG.4Ki	60.67
5	SKG.3Ka	46.08
6	SKG.3Ki	62.99
7	SKG.2Ka	80.35
8	SKG.2Ki	65.40
9	SKG.1Ki	43.50

Kurik 5&6 Irrigation Collector irrigation services

Table 4-5 Kurik 5&6 Irrigation Collector irrigation services

No	Collector Block	Area (ha)	No	Collector Block	Area (ha)	No	Collector Block	Area (ha)
1	KMU.1-8ki	22.0	36	SMA.1-10ki	54.1	71	SMA.5-3ki	31.4
2	KMU.1-7ka	45.0	37	SMA.1-9ki	53.8	72	SMA.5-2ka	34.2
3	KMU.1-6ka	49.0	38	SMA.1-8ki	57.6	73	SMA.5-1ka	32.7

No	Collector Block	Area (ha)	No	Collector Block	Area (ha)	No	Collector Block	Area (ha)
4	KMU.1-5ka	57.2	39	SMA.1-7ki	56.8	74	JMK.1-8ka	62.7
5	KMU.1-4ka	65.0	40	SMA.1-6ki	57.3	75	JMK.1-7ka	40.5
6	KMU.1-3ka	69.6	41	SMA.1-5ki	51.9	76	JMK.1-6ka	42.8
7	KMU.1-2ka	84.6	42	SMA.1-4ki	48.6	77	JMK.1-5ka	27.8
8	KMU.1-1ka	65.7	43	SMA.1-3ki	54.9	78	JMK.1-4ka	53.6
9	KMU.2-7ka	22.2	44	SMA.1-2ki	49.4	79	JMK.1-3ka	65.1
10	KMU.2-6ki	61.5	45	SMA.1-1ki	23.9	80	JMK.1-2ka	59.6
11	KMU.2-5ka	19.9	46	SMA.2-6ka	13.9	81	JMK.1-1ka	28.4
12	KMU.2-4ka	15.9	47	SMA.2-5ka	14.7	82	JMK.2-4ka	56.9
13	KMU.3-2ki	42.6	48	SMA.2-4ka	22.1	83	JMK.2-3ka	67.0
14	KMU.3-1ki	44.9	49	SMA.2-3ki	9.9	84	JMK.2-2ka	60.6
15	KMU.4-12ka	43.1	50	SMA.2-3ka1	15.9	85	JMK.2-1ka	53.0
16	KMU.4-11ka	39.9	51	SMA.2-3ka2	35.1			
17	KMU.4-10ka	41.4	52	SMA.2-2ka	18.2			
18	KMU.4-9ka	39.5	53	SMA.2-2ki	15.7			
19	KMU.4-8ka	28.7	54	SMA.2-1ka	16.2			
20	KMU.4-7ka	18.7	55	SMA.2-1ki	14.5			
21	KMU.4-6ka	12.8	56	SMA.3-7ki	16.1			
22	KMU.4-5ka	16.2	57	SMA.3-6ki	31.1			
23	KMU.4-4ka	13.2	58	SMA.3-5ki	45.1			
24	KMU.4-3ka	14.7	59	SMA.3-4ka	14.8			
25	KMU.4-2ka	14.4	60	SMA.3-4ki	61.8			
26	KMU.4-1ka	16.9	61	SMA.3-3ka	26.8			
27	KMU.5-6ki	12.9	62	SMA.3-2ki	93.2			
28	KMU.5-5ka	53.8	63	SMA.3-1ka	23.6			
29	KMU.5-5ki	10.2	64	SMA.4-5ki	22.4			
30	KMU.5-4ka	46.2	65	SMA.4-4ki	24.9			
31	KMU.5-4ki	8.0	66	SMA.4-3ki	29.6			
32	KMU.5-3ki	8.9	67	SMA.4-2ki	29.1			
33	KMU.5-2ki	9.0	68	SMA.4-1ki	29.9			
34	KMU.5-1ki	10.5	69	SMA.5-4ki	15.4			
35	SMA.1-11ki	27.7	70	SMA.5-4ka	10.6			

4.4.2.2 Collector irrigation services area of Salor

Table 4-6 Salor 1 irrigation area services

No.	Collector Block	Area (ha)
1	TSR 3-3 Te	79.8
2	TSR 3-3 Ka 2	49.4
3	TSR 3-3 Ka 1	54.2
4	TSR 3-3 Ki	49.4
5	TSR 3-2 Ka	50.4

No.	Collector Block	Area (ha)
6	TSR 3-2 Ki	50.4
7	TSR 3-1 Ka	65.6
8	TSR 2-3 Ki 2	39.9
9	TSR 2-3 Ki 1	47.5
10	TSR 2-2 Ki	54.2
11	TSR 2-1 Ki	55.1
12	TSR 1-5 Te	67.5
13	TSR 1-5 Ka	73.2
14	TSR 1-4 Ka	40.9
15	TSR 1-3 Ki	55.1
16	TSR 1-2 Ki	78.9
17	TSR 1-1 Ka	52.3
18	SLR I-3 Ka	56.1
19	SLR I-3 Ki	63.7
20	SLR I-2 Ka	79.8
21	SLR I-1 Ki	36.1
22	SBH-5 Ki	34.2

Table 4-7 Salor 2 & 4 irrigation area services

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	SIV-4 Ka2	32.2	21	SLR II-7 Ka	35.7	41	HMA.1-3 Ka	44.1
2	SIV-4 Ka1	30.8	22	SLR II-6 Ka 1	36.4	42	HMA.1-3 Ki	23.3
3	SIV-4 Ki	38.5	23	SLR II-6 Ka 2	32.9	43	HMA.1-1 Ka	32.2
4	SIV-3 Ka	32.2	24	SLR II-6 Ka 3	28.0	44	HMA.1-1 Ki	39.9
5	SIV-2 Ka	33.6	25	SLR II-5 Ka 2	26.6	45	SBR-2 Ka 1	33.6
6	SIV-1 Ka	27.3	26	SLR II-5 Ka 1	32.9	46	SBR-2 Ka 2	58.8
7	SHM-4 Ka	40.6	27	SLR II-4 Ki	34.3	47	SBR-1 Ka	32.9
8	SHM-3 Ka	35.0	28	SLR II-3 Ka	31.5	48	SRJ-4 Ka	50.4
9	SHM-2 Ka	35.0	29	SLR II-2 Ki	30.1	49	SRJ-4 Ki	57.0
10	SHM-1 Ka2	35.7	30	SLR II-1 Ka 1	31.5	50	SRJ-3 Ka 1	48.5
11	SHM-1 Ka 1	35.0	31	SLR II-1 Ka 2	39.2	51	SRJ-3 Ka 2	39.9
12	SLR II-9 Ka2	34.3	32	HMA.3-2 Ki 2	35.7	52	SRJ-2 Ka	13.3
13	SLR II-9 Ka 1	36.4	33	HMA.3-2 Ki 1	31.5	53	SRJ-1 Ka 1	39.0
14	SLR II-9 Ki	40.6	34	HMA.3-1 Ki 1	26.6	54	SRJ-1 Ka 2	46.6
15	SI-3 PMI	25.4	35	HMA.3-1 Ki 2	43.4	55	SRJ-1 Ki 1	39.9
16	SI-2 PMI	12.6	36	HMA.3-1 Ki 3	41.3	56	SRJ-1 Ki 2	57.0
17	SI-1 PMI	17.8	37	HMA.2-1 Ki 1	37.8	57	SLR I.2-4 Ka	43.7
18	SLR II-8 PMI2	16.5	38	HMA.2-1 Ki 2	27.3	58	SLR I.2-4 Ki	41.8
19	SLR II-8 PMI1	27.6	39	HMA.2-1 Ka	14.7			
20	SLR II-7 Ki	28.7	40	HMA.2-1 PMI	31.0			

Table 4-8 Salor 3 irrigation area services

No.	Collector Block	Area (ha)
1	SK-1 Ki 1	53.2
2	SK-1 Ki 2	43.7
3	WRJ-1 Ka 1	29.5
4	WRJ-1 Ka 2	67.5
5	WRJ-1 Ki 1	53.2
6	WRJ-1 Ki 2	36.1
7	WRJ-2 Ki	44.7
8	WRJ-2 PMI	5.1
9	WRJ-3 Ka	79.8
10	WRJ-4 Ka	41.3
11	WRJ-7 Ki1	23.1
12	WRJ-7 Ki2	31.5
13	WRJ-8 Ka	30.1
14	WRJ-8 Ki	40.6

4.4.2.3 Collector irrigation services area of Kuprik Sidomulyo

Table 4-9 Kuprik Sidomulyo irrigation area services

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	KSD 1 Ki	14.9	31	SML 1.5 Ki	22.7	61	URM 1.2 Ka	18.2
2	KSD 10 Ki 1	5.2	32	SML 1.6 Ka	61.5	62	URM 1.2 Ki	18.2
3	KSD 10 Ki 2	28.3	33	SML 1.6 Ki	10.9	63	URM 1.3 Ka	17.9
4	KSD 11 Ki	54.4	34	SML 1.7 Ka	14.8	64	URM 1.3 Ki	18.2
5	KSD 12 Ki	54.2	35	SML 1.8 Ka	19.4	65	URM 1.4 Ka	19.0
6	KSD 2 Ki	15.7	36	SML 1.8 Ki	30.8	66	URM 1.4 Ki	19.8
7	KSD 3 Ki	22.7	37	SML 2.1 Ka	11.0	67	URM 2.1 Ki	18.6
8	KSD 4 Ki	10.9	38	SML 2.1 Ki	11.3	68	URM 2.2 Ki	18.3
9	KSD 5 Ki	18.8	39	SML 2.2 Ki	5.5	69	URM 2.3 Ki	18.3
10	KSD 6 Ki	19.4	40	SML 2.3 Ka	14.7	70	URM 2.4 Ki	17.8
11	KSD 7 Ki	24.9	41	SML 2.3 Ki	9.3	71	URM 2.5 Ka	6.3
12	KSD 8 Ki	21.6	42	SML 3.1 Ki	18.8	72	URM 2.5 Ki	25.7
13	KSD 9 Ki	7.3	43	SML 3.2 Ka	37.5	73	URM 2.6 Ki 1	5.4
14	SJY 1 Ki	16.0	44	SML 3.3 Ki	19.9	74	URM 2.6 Ki 2	35.7
15	SJY 2 Ki	20.1	45	SML 3.4 Ka	21.5	75	URM 2.7 Ka	13.2
16	SJY 3 Ka	28.3	46	SML 3.4 Ki	10.0	76	URM 2.8 Ka	14.1
17	SJY 3 Ki	33.0	47	SML 3.5 Ki	17.3	77	KSD 15 Ki	20.7
18	SJY 4 Ka	36.3	48	SML 3.6 Ka	22.0	78	KSD 16 Ki	29.5

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
19	SJY 4 Ki	71.8	49	SML 4.1 Ka	20.0	79	KSD 17 Ki	34.2
20	SJY 5 Ka	70.0	50	SML 4.1 Ki	31.5	80	KSD 18 Ki	17.2
21	SJY 6 Ki	34.6	51	SML 4.2 Ka	16.5			
22	SJY 7 Ka	55.0	52	SML 4.2 Ki	30.2			
23	SJY 7 Ki	37.0	53	SML 4.3 Ka	21.8			
24	SML 1.1 Ka 1	11.2	54	SML 4.3 Ki	47.0			
25	SML 1.1 Ka 2	5.1	55	SML 4.4 Ka 1	25.5			
26	SML 1.2 Ka	20.5	56	SML 4.4 Ka 2	28.0			
27	SML 1.3 Ka	9.0	57	SML 4.4 Ki 1	17.4			
28	SML 1.4 Ka	17.9	58	SML 4.4 Ki 2	29.1			
29	SML 1.4 Ki	18.3	59	URM 1.1 Ka	19.1			
30	SML 1.5 Ka	15.3	60	URM 1.1 Ki	18.8			

4.4.2.4 Collector irrigation service area of Tanah Miring SP9

Table 4-10 Tanah Miring SP9 irrigation area services

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	TM9 1.1 Ki	55.0	27	YMU 1.5 Ki	42.0
2	TM9 1.2 Ki	57.0	28	YMU 1.6 Ka	44.0
3	TM9 1.3 Ki	26.0	29	YMU 1.7 Ka	47.0
4	TM9 1.4 Ka	28.0	30	YMU 2.1 Ka	56.0
5	TM9 1.5 Ka	25.0	31	YMU 2.2 Ka	40.0
6	TM9 2.1 Ka	22.0	32	YMU 3.2 Ka	22.0
7	TM9 2.2 Ka	30.0	33	YMU 3.2 Ki	14.0
8	TM9 2.3 Ka	41.0	34	YMU 3.3 Ka	33.0
9	TM9 2.4 Ka	42.0	35	YMU 3.3 Ki	29.0
10	TM9 3.1 Ki 1	20.0	36	YMU 3.4 Ka	33.0
11	TM9 3.1 Ki 2	33.0	37	YMU 3.4 Ki	30.0
12	TM9 3.10 Ki	68.0	38	YMU 3.5	35.0
13	TM9 3.11 Ki	52.0	39	YMU 4.1 Ka	26.0
14	TM9 3.12 Ki	36.0	40	YMU 4.1 Ki	26.0
15	TM9 3.13 Ki	47.0	41	YMU 4.2 Ka	24.0
16	TM9 3.3 Ki	48.0	42	YMU 4.2 Ki	33.0
17	TM9 3.4 Ki	24.0	43	YMU 5.1 Ka	42.0
18	TM9 3.5 Ki	49.0	44	YMU 5.1 Ki	39.0
19	TM9 3.6 Ki	50.0	45	YMU 5.2 Ka	43.0
20	TM9 3.7 Ki	41.0	46	YMU 5.2 Ki	41.0
21	TM9 3.8 Ki	48.0	47	YMU 6.1 Ki	22.0
22	TM9 3.9 Ki	24.0	48	YMU 6.2 Ka	29.0
23	YMU 1.1 Ki	43.0	49	YMU 6.2 Ki	27.0

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
24	YMU 1.2 Ki	44.0	50	YMU 6.3 Ka	20.0
25	YMU 1.3 Ki	43.0	51	YMU 6.4 Ka	17.0
26	YMU 1.4 Ki	44.0	52	YMU 6.5 Ka	38.0

4.4.2.5 Collector irrigation service area of Tanah Miring SP 2,4 and 7

Table 4-11 Tanah Miring SP 2,4, and 7 irrigation service area

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	TM 1 Ki	66.5	39	TM4 2.4 Ki	33.3
2	TM2 1 Ka	17.1	40	TM4 2.5 Ki	22.8
3	TM2 2 Ka	30.4	41	TM4 2.7 Ki	42.8
4	TM2 2 Ki	26.6	42	TM4 2.8 Ki	38.0
5	TM2 3 Ka	30.4	43	TM7 2.1 Ki	29.5
6	TM2 3 Ki	29.5	44	WS 1.1 Ki	32.3
7	TM2 4 Ka	30.4	45	WS 1.2 Ka	20.9
8	TM2 5 Ki	45.6	46	WS 1.2 Ki	29.5
9	TM2 6 Ka	31.4	47	WS 1.3 Ka	17.1
10	TM2 7 Ka	29.5	48	WS 1.3 Ki	29.5
11	TM2 7 Ki	32.3	49	WS 1.4 Ka	25.7
12	TM2 8 Ka	36.1	50	WS 1.5 Ki	36.1
13	TM2 8 Ki	33.3	51	WS 2.1 Ka	39.9
14	TM2 10 Ka	39.9	52	WS 2.2 ka	36.1
15	TM2 10 Ki	37.1	53	YMA 2.2 Ka	47.5
16	TM4 2.1 Ki	53.2	54	TM7 1.1 Ka	38.0
17	TM4 2.2 Ki	36.1	55	TM7 1.2 Ka	30.4
18	YMA 1.1 Ka	11.4	56	TM7 1.3 Ka	34.2
19	YMA 1.1 Ki	21.9	57	TM7 1.4 Ka	52.3
20	YMA 1.2 Ki	37.1	58	TM7 1.5 Ka	39.9
21	YMA 1.3 Ki	27.6	59	TM7 1.6 Ka	43.7
22	YMA 2.1 Ka	5.7	60	TM7 1.7 Ka	34.2
23	YMA 2.2 Ki	17.1	61	TM7 1.9 Ka	33.3
24	YMA 2.3 Ka 1	16.2	62	TM7 1.9 Ki	29.5
25	YMA 2.3 Ka 2	29.5	63	TM7 1.10 Ka	35.2
26	YMA 2.4 Ki	33.3	64	TM7 1.11 Ki	55.1
27	YMA 2.5 Ki	34.2	65	TM7 1.11 Ka	34.2
28	YMA 3.1 Ka	18.1	66	TM7 2.3	45.6
29	YMA 3.1 Ki	20.9	67	TM7 2.4	22.8
30	YMA 3.2 Ka	39.9	68	TM7 2.5	25.7
31	YMA 3.3 Ki	31.4	69	TM7 2.6 Ka	20.0
32	HB 1.2 Ki	16.2	70	TM7 2.7 Ka	40.9

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
33	HB 1.3 Ki	12.4	71	TM7 2.7 Ki	12.4
34	HB 2.1 Ki	15.2	72	TM7 2.8 Ka	39.9
35	HB 2.2 Ki	15.2	73	TM7 2.9 Ka	35.2
36	HB 2.3 Ki	15.2			
37	HB 2.4 Ki	9.5			
38	TM4 1.1 Ka	17.1			

4.4.2.6 Collector irrigation service area of Sermayam New

Table 4-12 Service area in Sermayam New

No.	Collector Block	Area (ha)
1	KMG 1-1 Ka	41.8
2	KMG 1-2 Ka	40.9
3	KMG 1-3 Ka	37.1
4	KMG 3-1 Ki	59.9
5	KMG 3-2 Ki	57.0
6	KMG 4-1 Ka	45.6
7	KMG 4-1 Ki	57.0
8	KMG 4-2 Ki	57.0
9	KMG 4-4 Ka	57.0
10	KMG 4-4 Ki	57.0
11	KMG 4-5 Ka	57.0
12	KMG 4-5 Ki	32.9
13	KMG 4-6 Ka	54.2
14	KMG 4-6 Ki	75.1
15	KMG 5-1 Ka	83.6
16	KMG 5-1 Ki	65.6
17	KMG 4-7 Ka	51.3
18	SRM 2 Ka	50.4
19	SRM 3 Ka	70.3
20	SRM 5 Ka	26.6
21	TM7 1.11 Ki	55.1
22	TMB 1 Ki	56.1
23	TMB 2 Ka	58.0

4.4.2.7 Collector irrigation service area of Lower Jagebob

Table 4-13 Service area in Jagebob Raya

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	JGR 4.4 Ki	31.3	16	JGR 2.3 Ka 2	66.4	31	JGR 1.4 Ki 1	47.2
2	JGR 4.4 Ka	71.7	17	JGR 2.3 Ka 1	24.4	32	JGR 1.3 Ki	83.1
3	JGR 4.3 Ka 2	49.5	18	JGR 2.2 Ka	24.0	33	JGR 1.2 Ki	102.6
4	JGR 4.3 Ka 1	35.0	19	JGR 2.1 Ka	42.6	34	JGR 1.1 Ki	46.5
5	JGR 4.2 Ka	44.6	20	JGR 10 Ka	22.4	35	JGR 7 Ki	45.7
6	JGR 4.1 Ka	55.9	21	JGR 9 Ki	63.0	36	JGR 6 Ki	44.2
7	JGR 3.6 Ki	25.5	22	JGR 8 Ki	47.3	37	JGR 5 Ki	42.4
8	JGR 3.5 Ki	55.2	23	JGR 1.8 Ki	70.5	38	JGR 4 Ki	40.9
9	JGR 3.5 Ka	49.2	24	JGR 1.7 Ki 2	47.0	39	JGR-3 PMI 3	69.8
10	JGR 3.4 Ki	45.5	25	JGR 1.7 Ki 1	47.8	40	JGR-3 PMI 2	47.2
11	JGR 3.3 Ki	33.1	26	JGR 1.6 Ki 2	48.9	41	JGR-3 PMI 1	46.9
12	JGR 3.2 Ki	58.2	27	JGR 1.6 Ki 1	51.8	42	JGR 3 Ki	19.2
13	JGR 3.1 Ki	41.3	28	JGR 1.5 Ki 2	77.4	43	JGR 2 Ki	37.2
14	JGR 2.4 Ka	50.5	29	JGR 1.5 Ki 1	66.8	44	JGR-1 PMI	40.1
15	JGR 2-3 PMI	60.4	30	JGR 1.4 Ki 2	53.6	45	JGR 1 Ki	38.2

Table 4-14 Service area in Mimi Baru

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	MMB 2.7 Ki	39.2	12	MMB 2.1 Ki 1	65.9
2	MMB 2.7 Ka	18.8	13	MMB 2-1 PMI	137.5
3	MMB 2.6 Ka	18.6	14	MMB 1.3 Ka	32.2
4	MMB 2.5 Ki	52.7	15	MMB 1.2 Ka	40.3
5	MMB 2.5 Ka	20.0	16	MMB 1.1 Ka	38.7
6	MMB 2.4 Ka 2	35.4	17	MMB 3 Ka	79.7
7	MMB 2.4 Ka 1	47.9	18	MMB 2 Ki	34.8
8	MMB 2.3 Ki	84.3	19	MMB 2 Ka	70.9
9	MMB 2.2 Ki	72.3	20	MMB 1 Ki 2	40.4
10	MMB 2.1 Ki 3	33.3	21	MMB 1 Ki 1	54.2
11	MMB 2.1 Ki 2	43.1	22	MMB 1 Ka	87.4

Table 4-15 Service area in Gurinda Jaya

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	GRJ 1.3 Ki	72.4	14	GRJ 3.2 Ka	18.9	27	KMS 2.6 Ki	40.2
2	GRJ 1.3 Ka	48.5	15	GRJ 3.1 Ki 2	65.5	28	KMS 2.5 Ki	36.6
3	GRJ 1.2 Ki	19.8	16	GRJ 3.1 Ki 1	77.0	29	KMS 2.4 Ki	14.4

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
4	GRJ 1.2 Ka 2	30.8	17	GRJ 3.1 Ka	47.6	30	KMS 2.3 Ki	17.3
5	GRJ 1.2 Ka 1	76.0	18	KMS 7 Ki	19.8	31	KMS 2.2 Ki	28.5
6	GRJ 1.1 Ki	47.3	19	KMS 6 Ka	72.6	32	KMS 2.1 Ki	15.1
7	GRJ 1.1 Ka	76.4	20	KMS 5 Ka 2	55.1	33	KMS 1.4 Ka	40.6
8	GRJ 1-1 PMI	53.4	21	KMS 5 Ka 1	38.5	34	KMS 1.3 Ka	69.6
9	GRJ 2-2 PMI 2	52.2	22	KMS 4 Ka	55.6	35	KMS 1.2 Ki	52.1
10	GRJ 2-2 PMI 1	30.7	23	KMS 3 Ki	73.6	36	KMS 1.2 Ka	30.9
11	GRJ 2.2 Ka	77.4	24	KMS 3 Ka	26.5	37	KMS 1.1 Ki	10.1
12	GRJ 2.1 Ki	31.0	25	KMS-2 PMI	106.4	38	KMS 1 Ki	23.2
13	GRJ 3.2 Ki	71.3	26	KMS 2 Ka	47.6	39	KMS 1 Ka	26.7

4.4.2.8 Collector irrigation service area of Kumbe Kampung

Table 4-16 Kumbe Kampung irrigation service area

No.	Collector Block	Area (ha)	No.	Collector Block	Area (ha)
1	Kb 1 Kn	45.0	11	Kb 5 Kn	17.0
2	Kb 1 Kr	42.0	12	Kb 5 Kr	12.0
3	Kb 2 Kn 1	11.0	13	Kb 6 Kn	20.0
4	Kb 2 Kn 2	53.0	14	Kb 6 Kr	20.0
5	Kb 2 Kr	10.0	15	Kb 7 Kn 1	109.0
6	Kb 3 Kn	9.0	16	Kb 7 Kn 2	10.0
7	Kb 3 Kr	10.0	17	Kb 7 Kr	3.0
8	Kb 4 Kn 1	16.0	18	Kb 8 Kn	34.0
9	Kb 4 Kn 2	25.0	19	Kb 8 Kr 1	1.0
10	Kb 4 Kr	23.0	20	Kb 8 Kr 2	9.0

4.4.3 Dimensions of primary and secondary supply lines for each block of schemes

4.4.3.1 Kurik lowland irrigation canal dimensions

Primary canal dimensions

Table 4-17 Salor Kurik Main Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP SK-R1	7,775	20,280	24.14	3.38	22.56	1.25	4.63	41.08
SP SK-R2	4,672	19,548	23.31	3.36	22.01	1.25	4.61	40.45
SP SK-R3	5,240	14,118	18.43	3.23	18.55	1.25	4.48	36.45

Table 4-18 Kurik 1 Primary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP KRK.1-R1	2,836	5,663	7.19	2.69	8.74	0.75	3.44	19.06
SP KRK.1-R2	3,350	3,911	4.99	2.51	6.68	0.60	3.11	16.01
SP KRK.1-R3	1,354	2,791	3.68	2.35	5.40	0.60	2.95	14.26
SP KRK.1-R4	1,126	2,512	3.35	2.31	5.07	0.60	2.91	13.78
SP KRK.1-R5	1,960	2,129	2.82	2.22	4.53	0.60	2.82	12.98
SP KRK.1-R6	988	1,272	1.72	1.96	3.36	0.60	2.56	11.03
SP KRK.1-R7	521	1,054	1.42	1.81	2.95	0.50	2.31	7.57

Table 4-19 Kurik 2 Primary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP KRK.2-R1	1,825	8,455	11.24	2.98	12.68	1.00	3.98	28.61
SP KRK.2-R2	526	7,931	10.51	2.95	12.04	1.00	3.95	27.84
SP KRK.2-R3	3,526	7,315	9.66	2.83	10.96	0.75	3.58	21.69
SP KRK.2-R4	304	6,134	8.18	2.75	9.64	0.75	3.50	20.13
SP KRK.2-R5	3,162	5,026	6.65	2.65	8.24	0.75	3.40	18.44
SP KRK.2-R6	289	3,987	5.31	2.54	6.98	0.75	3.29	16.85
SP KRK.2-R7	2,809	1,546	2.14	2.07	3.82	0.60	2.67	11.83

Kurik 1 secondary canal dimensions

Table 4-20 Kaliki 5 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KLK.5-R1	252	384	0.51	0.85	1.14	0.50	1.35	3.83
SS KLK.5-R2	410	316	0.42	0.80	1.05	0.40	1.20	3.44
SS KLK.5-R3	412	268	0.35	0.76	0.99	0.40	1.16	3.30
SS KLK.5-R4	427	219	0.29	0.71	0.91	0.40	1.11	3.13
SS KLK.5-R5	398	170	0.22	0.65	0.83	0.40	1.05	2.94
SS KLK.5-R6	242	148	0.20	0.63	0.79	0.40	1.03	2.84
SS KLK.5-R7	531	99	0.13	0.55	0.68	0.40	0.95	2.58
SS KLK.5-R8	627	39	0.05	0.41	0.49	0.40	0.81	2.10

Table 4-21 Rawasari 1 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS RWS.1-R1	1,426	189	0.25	0.70	0.89	0.40	1.10	3.09
SS RWS.1-R2	789	125	0.16	0.61	0.76	0.40	1.01	2.79
SS RWS.1-R3	916	66	0.09	0.50	0.61	0.40	0.90	2.41

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS RWS.1-R4	122	42	0.05	0.43	0.52	0.40	0.83	2.17
SS RWS.1-R5	125	25	0.03	0.36	0.43	0.40	0.76	1.95

Table 4-22 Rawasari 2 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS RWS.2-R1	284	497	0.66	1.12	1.56	0.50	1.62	4.80
SS RWS.2-R2	409	452	0.60	1.09	1.50	0.50	1.59	4.68
SS RWS.2-R3	413	413	0.55	1.06	1.44	0.50	1.56	4.56
SS RWS.2-R4	510	375	0.50	1.03	1.39	0.40	1.43	4.24
SS RWS.2-R5	520	316	0.42	0.98	1.29	0.40	1.38	4.04

Table 4-23 Rawasari 3 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS RWS.3-R1	285	218	0.29	0.70	0.90	0.40	1.10	3.09
SS RWS.3-R2	414	173	0.23	0.65	0.82	0.40	1.05	2.92
SS RWS.3-R3	412	134	0.18	0.60	0.75	0.40	1.00	2.74
SS RWS.3-R4	453	97	0.13	0.54	0.66	0.40	0.94	2.54
SS RWS.3-R5	77	47	0.06	0.42	0.51	0.40	0.82	2.16

Table 4-24 Rawasari 4 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS RWS.4-R1	235	124	0.16	0.82	1.02	0.40	1.22	3.47
SS RWS.4-R2	409	56	0.07	0.63	0.77	0.40	1.03	2.84

Table 4-25 Kumbe 1 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMB.1-R1	971	275	0.36	0.93	1.22	0.40	1.33	3.89
SS KMB.1-R2	113	245	0.32	0.90	1.17	0.40	1.30	3.77
SS KMB.1-R3	416	197	0.26	0.84	1.07	0.40	1.24	3.55
SS KMB.1-R4	122	173	0.23	0.81	1.02	0.40	1.21	3.43
SS KMB.1-R5	439	145	0.19	0.76	0.95	0.40	1.16	3.28
SS KMB.1-R6	450	59	0.08	0.57	0.69	0.40	0.97	2.62

Table 4-26 Kumbe 2 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMB.2-R1	1,654	930	1.19	1.46	2.27	0.50	1.96	6.18
SS KMB.2-R2	1,574	613	0.77	1.31	1.88	0.50	1.81	5.50
SS KMB.2-R3	926	380	0.46	1.14	1.53	0.40	1.54	4.62
SS KMB.2-R4	531	282	0.33	1.03	1.34	0.40	1.43	4.21
SS KMB.2-R5	519	251	0.29	0.99	1.27	0.40	1.39	4.05
SS KMB.2-R6	1,477	206	0.23	0.92	1.17	0.40	1.32	3.81
SS KMB.2-R7	1,238	170	0.19	0.86	1.07	0.40	1.26	3.59
SS KMB.2-R8	1,154	33	0.04	0.53	0.65	0.40	0.93	2.51

Table 4-27 Kumbe 3 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMB.3-R1	206	317	0.42	0.99	1.31	0.40	1.39	4.08
SS KMB.3-R2	394	226	0.30	0.89	1.14	0.40	1.29	3.72
SS KMB.3-R3	447	154	0.20	0.79	0.99	0.40	1.19	3.36
SS KMB.3-R4	527	70	0.09	0.61	0.74	0.40	1.01	2.76

Table 4-28 Kumbe 4 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMB.4-R1	217	233	0.31	0.90	1.16	0.40	1.30	3.75
SS KMB.4-R2	380	169	0.22	0.81	1.02	0.40	1.21	3.45
SS KMB.4-R3	124	139	0.18	0.76	0.95	0.40	1.16	3.27
SS KMB.4-R4	202	108	0.14	0.70	0.87	0.40	1.10	3.07
SS KMB.4-R5	876	64	0.09	0.59	0.72	0.40	0.99	2.71

Kurik 2 & Salor Kampung secondary canal dimensions

Table 4-29 Kaliki 1 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KLK.1-R1	1,029	744	0.98	1.39	2.09	0.50	1.89	5.87
SS KLK.1-R2	1,613	355	0.47	1.12	1.50	0.40	1.52	4.53
SS KLK.1-R3	423	315	0.42	1.08	1.43	0.40	1.48	4.38
SS KLK.1-R4	453	140	0.19	0.83	1.04	0.40	1.23	3.51
SS KLK.1-R5	425	106	0.14	0.76	0.94	0.40	1.16	3.26
SS KLK.1-R6	422	63	0.08	0.64	0.78	0.40	1.04	2.87

Table 4-30 Kaliki 2 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KLK.2-R1	1,385	359	0.47	1.15	1.55	0.40	1.55	4.65
SS KLK.2-R2	514	328	0.43	1.12	1.49	0.40	1.52	4.53
SS KLK.2-R3	534	253	0.33	1.03	1.34	0.40	1.43	4.21

Table 4-31 Kaliki 3 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KLK.3-R1	660	115	0.15	0.80	1.00	0.40	1.20	3.40
SS KLK.3-R2	608	72	0.10	0.69	0.85	0.40	1.09	3.03
SS KLK.3-R3	389	38	0.05	0.56	0.68	0.40	0.96	2.60
SS KLK.3-R4	354	16	0.02	0.42	0.51	0.40	0.82	2.16

Table 4-32 Kaliki 4 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KLK.4-R1	917	184	0.24	0.93	1.19	0.40	1.33	3.85
SS KLK.4-R2	417	137	0.18	0.85	1.06	0.40	1.25	3.56
SS KLK.4-R3	419	91	0.12	0.74	0.92	0.40	1.14	3.20
SS KLK.4-R4	414	46	0.06	0.59	0.72	0.40	0.99	2.71

Table 4-33 Harapan Makmur Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS HMA-R1	1,775	203	0.27	0.94	1.20	0.40	1.34	3.87
SS HMA-R2	673	128	0.17	0.83	1.04	0.40	1.23	3.50
SS HMA-R3	413	80	0.11	0.71	0.87	0.40	1.11	3.10
SS HMA-R4	575	44	0.06	0.58	0.71	0.40	0.98	2.68

Table 4-34 Ivimahad 1 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS IVM.1-R1	5,219	1,752	2.10	1.78	3.26	0.60	2.38	10.40
SS IVM.1-R2	440	1,675	1.99	1.76	3.17	0.60	2.36	10.24
SS IVM.1-R3	781	1,583	1.87	1.73	3.05	0.60	2.33	10.04
SS IVM.1-R4	459	1,546	1.82	1.72	3.01	0.60	2.32	9.96
SS IVM.1-R5	318	1,467	1.72	1.69	2.91	0.60	2.29	9.78
SS IVM.1-R6	1,203	1,357	1.58	1.65	2.77	0.60	2.25	9.53
SS IVM.1-R7	900	522	0.64	1.19	1.66	0.50	1.69	5.05

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS IVM.1-R8	466	502	0.62	1.18	1.63	0.50	1.68	4.99
SS IVM.1-R9	430	433	0.53	1.12	1.53	0.50	1.62	4.77
SS IVM.1-R10	223	359	0.43	1.06	1.40	0.40	1.46	4.31
SS IVM.1-R11	249	326	0.38	1.02	1.34	0.40	1.42	4.18
SS IVM.1-R12	223	271	0.33	0.97	1.26	0.40	1.37	4.01
SS IVM.1-R13	400	206	0.25	0.89	1.12	0.40	1.29	3.70
SS IVM.1-R14	417	102	0.12	0.71	0.87	0.40	1.11	3.08

Table 4-35 Ivimahad 2 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS IVM.2-R1	242	242	0.32	1.04	1.35	0.40	1.44	4.23
SS IVM.2-R2	431	229	0.30	1.02	1.32	0.40	1.42	4.17
SS IVM.2-R3	194	207	0.27	0.99	1.27	0.40	1.39	4.06
SS IVM.2-R4	660	188	0.25	0.96	1.22	0.40	1.36	3.95
SS IVM.2-R5	668	142	0.19	0.88	1.10	0.40	1.28	3.66
SS IVM.2-R6	1,081	105	0.14	0.80	0.99	0.40	1.20	3.38
SS IVM.2-R7	427	95	0.13	0.77	0.95	0.40	1.17	3.30
SS IVM.2-R8	346	72	0.09	0.70	0.86	0.40	1.10	3.07
SS IVM.2-R9	790	43	0.06	0.60	0.72	0.40	1.00	2.71

Table 4-36 Salor Kampung Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SKG-R1	1,652	487	0.47	1.18	1.58	0.40	1.58	4.74
SS SKG-R2	649	443	0.43	1.15	1.52	0.40	1.55	4.61
SS SKG-R3	649	298	0.29	1.01	1.30	0.40	1.41	4.12
SS SKG-R4	694	188	0.18	0.87	1.09	0.40	1.27	3.64
SS SKG-R5	680	70	0.07	0.63	0.77	0.40	1.03	2.83

Kurik 5 & 6 secondary canal dimensions

Table 4-37 Sukamaju 1 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMU.1-R1	397	458	0.60	0.97	1.34	0.50	1.47	4.28
SS KMU.1-R2	533	392	0.52	0.92	1.25	0.50	1.42	4.10
SS KMU.1-R3	383	308	0.41	0.86	1.13	0.40	1.26	3.65
SS KMU.1-R4	449	238	0.31	0.79	1.02	0.40	1.19	3.41
SS KMU.1-R5	415	173	0.23	0.72	0.90	0.40	1.12	3.13

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMU.1-R6	368	116	0.15	0.63	0.78	0.40	1.03	2.84
SS KMU.1-R7	526	67	0.09	0.53	0.64	0.40	0.93	2.49
SS KMU.1-R8	694	22	0.03	0.36	0.44	0.40	0.76	1.96

Table 4-38 Sukamaju 2 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMU.2-R1	744	1,983	2.42	1.79	3.46	0.60	2.39	10.64
SS KMU.2-R2	1,365	1,746	2.11	1.73	3.18	0.60	2.33	10.18
SS KMU.2-R3	765	1,658	1.99	1.71	3.08	0.60	2.31	10.00
SS KMU.2-R4	93	1,482	1.76	1.65	2.86	0.60	2.25	9.63
SS KMU.2-R5	394	1,466	1.74	1.65	2.85	0.60	2.25	9.59
SS KMU.2-R6	278	1,446	1.71	1.64	2.82	0.60	2.24	9.55
SS KMU.2-R7	172	896	1.10	1.42	2.17	0.50	1.92	6.01
SS KMU.2-R8	348	874	1.07	1.41	2.14	0.50	1.91	5.96

Table 4-39 Sukamaju 3 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMU.3-R1	570	87	0.12	0.73	0.90	0.40	1.13	3.17
SS KMU.3-R2	402	43	0.06	0.58	0.70	0.40	0.98	2.66

Table 4-40 Sukamaju 4 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMU.4-R1	270	488	0.53	1.20	1.63	0.50	1.70	5.02
SS KMU.4-R2	545	472	0.51	1.18	1.60	0.50	1.68	4.96
SS KMU.4-R3	507	457	0.49	1.17	1.57	0.40	1.57	4.71
SS KMU.4-R4	494	443	0.47	1.15	1.55	0.40	1.55	4.65
SS KMU.4-R5	383	240	0.32	1.02	1.31	0.40	1.42	4.15
SS KMU.4-R6	531	224	0.30	1.00	1.28	0.40	1.39	4.07
SS KMU.4-R7	402	211	0.28	0.98	1.25	0.40	1.38	4.00
SS KMU.4-R8	225	193	0.25	0.95	1.21	0.40	1.35	3.90
SS KMU.4-R9	410	164	0.22	0.90	1.14	0.40	1.30	3.74
SS KMU.4-R10	413	124	0.16	0.82	1.03	0.40	1.22	3.47
SS KMU.4-R11	414	83	0.11	0.72	0.89	0.40	1.12	3.13
SS KMU.4-R12	615	43	0.06	0.58	0.71	0.40	0.98	2.67

Table 4-41 Sukamaju 5 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMU.5-R1	318	160	0.21	0.89	1.12	0.40	1.29	3.71
SS KMU.5-R2	559	149	0.20	0.87	1.10	0.40	1.27	3.64
SS KMU.5-R3	492	140	0.18	0.86	1.07	0.40	1.26	3.58
SS KMU.5-R4	468	131	0.17	0.84	1.05	0.40	1.24	3.52
SS KMU.5-R5	418	77	0.10	0.70	0.86	0.40	1.10	3.07
SS KMU.5-R6	568	13	0.02	0.39	0.47	0.40	0.79	2.05

Table 4-42 Sumbermulya 1 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SMA.1-R1	2,481	536	0.71	1.32	1.87	0.50	1.82	5.52
SS SMA.1-R2	346	512	0.68	1.31	1.83	0.50	1.81	5.45
SS SMA.1-R3	456	463	0.61	1.27	1.75	0.50	1.77	5.29
SS SMA.1-R4	442	408	0.54	1.22	1.66	0.50	1.72	5.10
SS SMA.1-R5	346	359	0.47	1.17	1.57	0.40	1.57	4.72
SS SMA.1-R6	431	307	0.41	1.12	1.48	0.40	1.52	4.51
SS SMA.1-R7	455	250	0.33	1.05	1.36	0.40	1.45	4.26
SS SMA.1-R8	488	193	0.25	0.97	1.23	0.40	1.37	3.96
SS SMA.1-R9	393	136	0.18	0.86	1.08	0.40	1.26	3.60
SS SMA.1-R10	415	82	0.11	0.73	0.90	0.40	1.13	3.16
SS SMA.1-R11	285	28	0.04	0.51	0.62	0.40	0.91	2.44

Table 4-43 Sumbermulya 2 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SMA.2-R1	1,227	176	0.23	0.93	1.18	0.40	1.33	3.84
SS SMA.2-R2	307	145	0.19	0.88	1.10	0.40	1.27	3.65
SS SMA.2-R3	382	112	0.15	0.80	1.00	0.40	1.20	3.40
SS SMA.2-R4	203	51	0.07	0.62	0.75	0.40	1.02	2.79
SS SMA.2-R5	449	29	0.04	0.51	0.62	0.40	0.91	2.45
SS SMA.2-R6	402	14	0.02	0.40	0.48	0.40	0.80	2.09

Table 4-44 Sumbermulya 3 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SMA.3-R1	98	715	0.86	1.38	2.01	0.50	1.88	5.76
SS SMA.3-R2	321	691	0.83	1.36	1.97	0.50	1.86	5.69
SS SMA.3-R3	149	598	0.71	1.30	1.83	0.50	1.80	5.43
SS SMA.3-R4	343	571	0.67	1.28	1.79	0.50	1.78	5.35

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SMA.3-R5	1,098	494	0.57	1.22	1.67	0.50	1.72	5.10
SS SMA.3-R6	397	449	0.51	1.18	1.59	0.50	1.68	4.94
SS SMA.3-R7	85	418	0.47	1.15	1.54	0.40	1.55	4.63

Table 4-45 Sumbermulya 4 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SMA.4-R1	403	278	0.28	0.98	1.26	0.40	1.38	4.02
SS SMA.4-R2	409	248	0.24	0.94	1.19	0.40	1.34	3.86
SS SMA.4-R3	406	219	0.21	0.89	1.12	0.40	1.29	3.69
SS SMA.4-R4	412	189	0.17	0.83	1.03	0.40	1.23	3.49
SS SMA.4-R5	401	164	0.13	0.77	0.95	0.40	1.17	3.30

Table 4-46 Sumbermulya 5 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SMA.5-R1	343	124	0.16	0.77	0.96	0.40	1.17	3.29
SS SMA.5-R2	809	92	0.12	0.69	0.86	0.40	1.09	3.04
SS SMA.5-R3	259	57	0.08	0.60	0.73	0.40	1.00	2.72
SS SMA.5-R4	419	26	0.03	0.46	0.55	0.40	0.86	2.27

Table 4-47 Jaya Makmur 1 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS JMK.1-R1	114	380	0.50	1.17	1.58	0.50	1.67	4.93
SS JMK.1-R2	317	352	0.46	1.15	1.53	0.40	1.55	4.63
SS JMK.1-R3	411	292	0.39	1.08	1.42	0.40	1.48	4.39
SS JMK.1-R4	412	227	0.30	1.00	1.29	0.40	1.40	4.09
SS JMK.1-R5	310	174	0.23	0.91	1.15	0.40	1.31	3.77
SS JMK.1-R6	452	146	0.19	0.86	1.08	0.40	1.26	3.60
SS JMK.1-R7	412	103	0.14	0.77	0.95	0.40	1.17	3.29
SS JMK.1-R8	560	63	0.08	0.65	0.80	0.40	1.05	2.90

Table 4-48 Jaya Makmur 2 Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS JMK.2-R1	521	237	0.31	1.01	1.30	0.40	1.41	4.12
SS JMK.2-R2	336	184	0.24	0.93	1.18	0.40	1.33	3.85
SS JMK.2-R3	519	124	0.16	0.82	1.02	0.40	1.22	3.46

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS JMK.2-R4	343	57	0.08	0.64	0.77	0.40	1.04	2.84

4.4.3.2 Salor lowland irrigation canal dimensions

Table 4-49 Salor Primary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP SLR 1-1	2,245	767	0.95	2.46	6.00	2.44	4.90	20.70
SP SLR 1-2	1,286	435	0.51	2.46	6.00	2.44	4.90	20.70
SP SLR 1-3	1,286	380	0.44	2.46	6.00	2.44	4.90	20.70
SP SLR 2-1	1,085	332	0.44	2.46	6.00	2.44	4.90	20.70
SP SLR 2-2	830	249	0.33	2.46	6.00	2.44	4.90	20.70
SP SLR 2-3	1,313	191	0.25	2.46	6.00	2.44	4.90	20.70
SP SLR 2-4	487	148	0.20	2.46	6.00	2.44	4.90	20.70
SP SLR 2-5a	250	2,316	2.26	2.46	6.00	2.44	4.90	20.70
SP SLR II-5	280	2,316	2.26	2.70	6.00	1.50	4.20	18.60
SP SLR II-6	501	2,215	2.15	2.70	6.00	1.50	4.20	18.60
SP SLR II-7	507	2,172	2.11	2.70	6.00	1.50	4.20	18.60
SP SLR II-8	435	1,285	1.23	2.20	6.00	1.50	3.70	17.10
SP SLR II-9	1,437	1,236	1.18	2.20	6.00	1.50	3.70	17.10
SP SLR II-10	395	1,151	1.09	2.20	6.00	1.50	3.70	17.10
SP SLR II-11	429	1,012	0.95	2.20	6.00	1.50	3.70	17.10
SP SLR II-12	707	920	0.86	1.70	6.00	1.50	3.20	15.60
SP SLR II-13	351	696	0.71	1.70	6.00	1.50	3.20	15.60

Table 4-50 Telaga Sari Secondary Supply Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS TSR 1-1	2,245	660	0.65	4.21	2.00	0.40	4.61	15.83
SS TSR 1-2 PMI	1,286	472	0.56	4.21	2.00	0.40	4.61	15.83
SS TSR 1-2	1,286	435	0.54	4.21	2.00	0.40	4.61	15.83
SS TSR 1-3 PMI	1,085	380	0.47	4.21	2.00	0.40	4.61	15.83
SS TSR 1-3	830	332	0.44	4.20	2.00	0.40	4.60	15.80
SS TSR 1-4	1,313	249	0.33	4.20	2.00	0.40	4.60	15.80
SS TSR 1-5	487	191	0.25	4.20	2.00	0.40	4.60	15.80
SS TSR 1-6	250	148	0.20	4.20	2.00	0.40	4.60	15.80
SS TSR 2-1	280	365	0.46	4.10	4.00	0.40	4.50	17.50
SS TSR 2-2	501	239	0.29	4.10	3.00	0.40	4.50	16.50
SS TSR 2-3	507	149	0.20	4.10	3.00	0.40	4.50	16.50
SS TSR 2-4	435	92	0.12	4.10	3.00	0.40	4.50	16.50
SS TSR 3-1	1,437	420	0.55	4.08	6.00	0.40	4.48	19.44
SS TSR 3-2	395	351	0.46	4.08	6.00	0.40	4.48	19.44
SS TSR 3-3	429	245	0.32	4.08	6.00	0.40	4.48	19.44

Table 4-51 Sumber Rejeki Secondary Supply Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS SRJ 1-1	680	412	0.40	4.08	4.00	0.40	4.48	17.44
SS SRJ 1-2	299	220	0.21	4.08	4.00	0.40	4.48	17.44
SS SRJ 1-3	727	206	0.20	4.08	4.00	0.40	4.48	17.44
SS SRJ 1-4	300	113	0.11	4.08	4.00	0.40	4.48	17.44

Table 4-52 Wonorejo Secondary Supply Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS WRJ-1	2,245	630	0.69	2.00	4.00	0.50	2.50	11.50
SS WRJ-2	1,286	434	0.44	2.00	4.00	0.50	2.50	11.50
SS WRJ-3	1,286	373	0.37	2.00	4.00	0.50	2.50	11.50
SS WRJ-4	1,085	289	0.26	2.00	4.00	0.50	2.50	11.50
SS WRJ-5	830	233	0.21	1.00	4.00	0.40	1.40	8.20
SS WRJ-6	1,313	195	0.18	1.00	4.00	0.40	1.40	8.20
SS WRJ-7	487	179	0.17	1.00	4.00	0.40	1.40	8.20
SS WRJ-8	250	101	0.10	1.00	4.00	0.40	1.40	8.20

Table 4-53 Harapan Makmur Secondary Canal

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS HMA.1-1	2,245	663	0.62	1.55	6.00	1.00	2.55	13.66
SS HMA.1-2	1,286	305	0.27	1.55	6.00	1.00	2.55	13.66
SS HMA.1-3	1,286	118	0.11	1.55	6.00	1.00	2.55	13.66
SS HMA.2-1 PMI	1,085	187	0.15	1.00	2.00	0.50	1.50	6.50
SS HMA.2-1	830	114	0.11	1.00	2.00	0.50	1.50	6.50
SS HMA.3-1	1,313	255	0.25	2.00	4.00	1.00	3.00	13.00
SS HMA.3-2	487	96	0.09	2.00	8.00	1.00	3.00	17.00

4.4.3.3 Jagebob canal dimensions

Table 4-54 Jagebob Raya Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP JGR 1	2,380	2,195	2.99	2.17	4.54	0.60	2.77	12.83
SP JGR 2	476	2,117	2.91	2.15	4.45	0.60	2.75	12.71
SP JGR 3	1,890	2,080	2.86	2.14	4.41	0.60	2.74	12.63
SP JGR 4	1,019	2,061	2.83	2.14	4.38	0.60	2.74	12.60
SP JGR 5	397	2,020	2.77	2.13	4.32	0.60	2.73	12.51

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP JGR 6	405	1,977	2.71	2.12	4.27	0.60	2.72	12.44
SP JGR 7	398	1,933	2.65	2.10	4.20	0.60	2.70	12.31
SP JGR 8	1,641	1,148	1.56	1.83	3.06	0.60	2.43	10.35
SP JGR 9	242	1,100	1.49	1.76	2.91	0.50	2.26	7.43
SP JGR 10	307	838	1.12	1.63	2.51	0.50	2.13	6.78
SP JGR 11	423	757	1.01	1.58	2.38	0.50	2.08	6.54
SP JGR 12	645	713	0.96	1.60	2.38	0.50	2.10	6.57
SP JGR 13	419	658	0.88	1.56	2.29	0.50	2.06	6.41

Table 4-55 Jagebob Raya 1 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS JGR 1.1	2,421	743	0.98	1.28	1.91	0.50	1.78	5.47
SS JGR 1.2	686	697	0.92	1.26	1.86	0.50	1.76	5.37
SS JGR 1.3	809	594	0.78	1.19	1.71	0.50	1.69	5.10
SS JGR 1.4	761	511	0.67	1.14	1.61	0.50	1.64	4.89
SS JGR 1.5	604	410	0.54	1.07	1.46	0.50	1.57	4.60
SS JGR 1.6	1,125	266	0.35	0.93	1.21	0.40	1.33	3.87
SS JGR 1.7	772	165	0.22	0.81	1.02	0.40	1.21	3.43
SS JGR 1.8	698	72	0.10	0.62	0.75	0.40	1.02	2.79

Table 4-56 Jagebob Raya 2 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS JGR 2.1	933	268	0.35	0.93	1.22	0.40	1.33	3.88
SS JGR 2.2	896	226	0.30	0.88	1.14	0.40	1.28	3.70
SS JGR 2.3	425	202	0.27	0.86	1.09	0.40	1.26	3.61
SS JGR 2.4	823	50	0.07	0.55	0.67	0.40	0.95	2.57

Table 4-57 Jagebob Raya 3 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS JGR 3.1	323	308	0.41	0.98	1.30	0.40	1.38	4.07
SS JGR 3.2	958	267	0.35	0.93	1.22	0.40	1.33	3.89
SS JGR 3.3	2,206	209	0.28	0.86	1.10	0.40	1.26	3.61
SS JGR 3.4	727	175	0.23	0.82	1.04	0.40	1.22	3.49
SS JGR 3.5	721	130	0.17	0.73	0.91	0.40	1.13	3.18
SS JGR 3.6	396	26	0.03	0.43	0.52	0.40	0.83	2.19

Table 4-58 Jagebob Raya 4 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS JGR 4.1	419	288	0.38	0.96	1.26	0.40	1.36	3.99
SS JGR 4.2	645	232	0.31	0.90	1.17	0.40	1.30	3.77
SS JGR 4.3	423	188	0.25	0.85	1.08	0.40	1.25	3.57
SS JGR 4.4	1,260	103	0.14	0.69	0.85	0.40	1.09	3.02

Table 4-59 Mimi Baru Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP MMB 1	748	1,234	1.63	1.87	3.17	0.60	2.47	10.59
SP MMB 2	670	1,057	1.38	1.75	2.83	0.50	2.25	7.32
SP MMB 3	537	951	1.23	1.70	2.68	0.50	2.20	7.08

Table 4-60 Mimi Baru 1 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS MMB 1.1	602	111	0.14	0.70	0.86	0.40	1.10	3.05
SS MMB 1.2	201	72	0.09	0.59	0.73	0.40	0.99	2.72
SS MMB 1.3	459	32	0.04	0.46	0.55	0.40	0.86	2.27

Table 4-61 Mimi Baru 2 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS MMB 2.1	555	760	0.93	1.26	1.87	0.50	1.76	5.40
SS MMB 2.2	1,294	480	0.64	1.13	1.57	0.50	1.63	4.83
SS MMB 2.3	1,011	317	0.41	0.97	1.29	0.40	1.37	4.03
SS MMB 2.4	621	233	0.30	0.89	1.14	0.40	1.29	3.71
SS MMB 2.5	567	149	0.19	0.77	0.96	0.40	1.17	3.30
SS MMB 2.6	305	77	0.10	0.63	0.77	0.40	1.03	2.82
SS MMB 2.7	310	58	0.07	0.55	0.67	0.40	0.95	2.58

Table 4-62 Kamnosari 2 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMS 2-1	495	91	0.12	0.66	0.82	0.40	1.06	2.95
SS KMS 2-2	1,963	77	0.10	0.63	0.77	0.40	1.03	2.82

Table 4-63 Kamnosari Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP KMS 1	1,094	1,611	2.10	1.98	3.64	0.60	2.58	11.38
SP KMS 2	743	1,326	1.71	1.88	3.23	0.60	2.48	10.68
SP KMS 3	760	1,100	1.44	1.75	2.87	0.50	2.25	7.37
SP KMS 4	438	1,067	1.39	1.74	2.81	0.50	2.24	7.29
SP KMS 5	907	959	1.24	1.68	2.64	0.50	2.18	7.00
SP KMS 6	594	916	1.18	1.65	2.57	0.50	2.15	6.88

Table 4-64 Kamnosari 1 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMS 1.1	271	237	0.31	0.90	1.16	0.40	1.30	3.76
SS KMS 1.2	88	223	0.29	0.88	1.13	0.40	1.28	3.69
SS KMS 1.3	621	200	0.26	0.85	1.09	0.40	1.25	3.59
SS KMS 1.4	363	161	0.21	0.80	1.00	0.40	1.20	3.40
SS KMS 1.5	562	110	0.14	0.70	0.86	0.40	1.10	3.05
SS KMS 1.6	1,399	1,011	0.05	0.50	0.60	0.40	0.90	2.39

Table 4-65 Gurinda Jaya 1 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS GRJ 1.1	1,366	425	0.53	1.06	1.45	0.50	1.56	4.57
SS GRJ 1.2	617	247	0.32	0.91	1.17	0.40	1.31	3.79
SS GRJ 1.3	1,081	121	0.15	0.71	0.89	0.40	1.11	3.11

Table 4-66 Gurinda Jaya 2 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS GRJ 2.1	810	472	0.58	1.09	1.50	0.50	1.59	4.69
SS GRJ 2.2	1,472	160	0.16	0.73	0.90	0.40	1.13	3.16

Table 4-67 Gurinda Jaya 3 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS GRJ 3.1	555	280	0.36	0.94	1.23	0.40	1.34	3.92
SS GRJ 3.2	1,501	90	0.11	0.65	0.79	0.40	1.05	2.89

4.4.3.4 Sermayam New lowland irrigation canal dimensions

Table 4-68 Sermayam Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP SRM 1	1,072	1,203	8.25	2.65	9.36	0.75	3.40	19.56
SP SRM 2	652	1,144	7.82	2.63	8.98	0.75	3.38	19.11
SP SRM 3	1,150	1,091	7.44	2.61	8.64	0.75	3.35	18.70
SP SRM 4	713	1,017	6.90	2.57	8.17	0.75	3.32	18.13
SP SRM 5	1,319	908	6.12	2.51	7.46	0.75	3.26	17.25

Table 4-69 Kamanggi Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KMG 1-1	2,245	126	0.17	0.74	0.92	0.40	1.14	3.19
SS KMG 1-2	1,286	82	0.11	0.64	0.79	0.40	1.04	2.87
SS KMG 1-3	1,286	39	0.04	0.45	0.54	0.40	0.85	2.24
SS KMG 3-1	1,085	123	0.16	0.73	0.91	0.40	1.13	3.17
SS KMG 3-2	830	60	0.08	0.58	0.70	0.40	0.98	2.66
SS KMG 4-1	1,313	757	1.00	1.28	1.93	0.50	1.78	5.49
SS KMG 4-2	487	649	0.86	1.23	1.79	0.50	1.73	5.24
SS KMG 4-3	250	589	0.78	1.19	1.71	0.50	1.69	5.09
SS KMG 4-4	280	432	0.57	1.09	1.49	0.50	1.59	4.66
SS KMG 4-5	501	312	0.41	0.98	1.30	0.40	1.38	4.07
SS KMG 4-6	507	190	0.25	0.84	1.07	0.40	1.24	3.55
SS KMG 4-7	435	54	0.07	0.56	0.68	0.40	0.96	2.60
SS KMG 5-1	611	157	0.21	0.79	1.00	0.40	1.19	3.38

Table 4-70 Tambat Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS TMB 1	408	59	0.35	0.94	1.22	0.40	1.34	3.90
SS TMB 2	1,513	109	0.65	1.13	1.58	0.50	1.63	4.85

4.4.3.5 Tanah Miring lowland irrigation canal dimensions

Table 4-71 Yabamaru Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS YMU 1.1	2,098	307	1.93	1.73	3.09	0.60	2.33	10.08
SS YMU 1.2	444	264	1.64	1.66	2.82	0.60	2.26	9.59
SS YMU 1.3	443	220	0.29	0.99	1.27	0.40	1.39	4.05
SS YMU 1.4	436	177	0.23	0.92	1.17	0.40	1.32	3.81
SS YMU 1.5	436	133	0.18	0.84	1.05	0.40	1.24	3.53
SS YMU 1.6	1,475	91	0.12	0.74	0.92	0.40	1.14	3.20
SS YMU 1.7	680	47	0.06	0.60	0.73	0.40	1.00	2.72
SS YMU 2.1	299	96	0.13	0.76	0.93	0.40	1.16	3.25
SS YMU 2.2	727	40	0.05	0.57	0.69	0.40	0.97	2.62
SS YMU 3.1	300	305	1.92	1.73	3.07	0.60	2.33	10.06
SS YMU 3.2	298	196	0.26	0.95	1.22	0.40	1.35	3.92
SS YMU 3.3	404	160	0.21	0.89	1.13	0.40	1.29	3.71
SS YMU 3.4	1,025	98	0.13	0.76	0.94	0.40	1.16	3.27
SS YMU 3.5	471	35	0.05	0.54	0.66	0.40	0.94	2.54
SS YMU 4.1	497	109	0.14	0.79	0.98	0.40	1.19	3.36
SS YMU 4.2	572	57	0.08	0.64	0.78	0.40	1.04	2.85
SS YMU 5.1	1,065	165	0.22	0.90	1.14	0.40	1.30	3.74
SS YMU 5.2	853	84	0.11	0.73	0.89	0.40	1.12	3.14
SS YMU 6.1	870	153	0.20	0.88	1.11	0.40	1.28	3.67
SS YMU 6.2	478	131	0.17	0.84	1.05	0.40	1.24	3.52
SS YMU 6.3	435	75	0.10	0.70	0.86	0.40	1.10	3.05
SS YMU 6.4	387	55	0.07	0.63	0.77	0.40	1.03	2.83
SS YMU 6.5	351	38	0.05	0.56	0.68	0.40	0.96	2.59

Table 4-72 Yasa Mulya Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS YMA 1	1,356	296	0.39	0.97	1.27	0.40	1.37	4.01
SS YMA 1.1	201	103	0.14	0.69	0.85	0.40	1.09	3.03
SS YMA 1.2	483	68	0.09	0.60	0.74	0.40	1.00	2.74
SS YMA 1.3	513	29	0.04	0.45	0.55	0.40	0.85	2.26
SS YMA 2.1	151	193	0.25	0.84	1.08	0.40	1.25	3.57
SS YMA 2.2	159	187	0.25	0.84	1.06	0.40	1.24	3.54
SS YMA 2.3	885	119	0.16	0.72	0.90	0.40	1.12	3.15
SS YMA 2.4	1,268	71	0.09	0.61	0.75	0.40	1.01	2.77
SS YMA 2.5	409	36	0.05	0.49	0.59	0.40	0.89	2.37
SS YMA 3.1	1,254	185	0.24	0.83	1.06	0.40	1.23	3.53
SS YMA 3.2	210	144	0.19	0.77	0.96	0.40	1.17	3.30
SS YMA 3.3	963	102	0.13	0.69	0.85	0.40	1.09	3.03

Table 4-73 Hidup Baru 2 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS HB 2.1	470	58	0.35	1.05	1.36	0.40	1.45	4.26
SS HB 2.2	408	42	0.25	0.95	1.20	0.40	1.35	3.89
SS HB 2.3	404	26	0.16	0.81	1.01	0.40	1.21	3.43
SS HB 2.4	446	10	0.06	0.59	0.72	0.40	0.99	2.70

Table 4-74 Hidup Baru 1 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS HB 1.1	117	211	1.29	1.52	2.41	0.50	2.02	6.45
SS HB 1.2	398	153	0.92	1.41	2.08	0.50	1.91	5.89
SS HB 1.3	495	136	0.82	1.36	1.96	0.50	1.86	5.68
SS HB 1.4	2,140	136	0.82	1.36	1.96	0.50	1.86	5.68

Table 4-75 Waninggap Say Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS WS 1.1	103	201	1.23	1.49	2.35	0.50	1.99	6.34
SS WS 1.2	302	167	1.01	1.41	2.13	0.50	1.91	5.96
SS WS 1.3	408	114	0.68	1.29	1.81	0.50	1.79	5.39
SS WS 1.4	313	65	0.39	1.09	1.43	0.40	1.49	4.40
SS WS 1.5	260	38	0.23	0.92	1.16	0.40	1.32	3.79
SS WS 2.1	489	80	0.48	1.16	1.55	0.40	1.56	4.67
SS WS 2.2	373	38	0.23	0.92	1.16	0.40	1.32	3.79

4.4.3.6 Kuprik Sidomulyo lowland irrigation canal dimensions

Table 4-76 Kuprik Sidomulyo Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP.KSD-1	812	5,061	7.02	2.58	8.27	0.75	3.33	18.25
SP.KSD-2	205	4,954	6.89	2.57	8.16	0.75	3.32	18.11
SP.KSD-3	381	4,912	6.83	2.57	8.11	0.75	3.32	18.07
SP.KSD-4	536	4,877	6.78	2.56	8.06	0.75	3.31	18.00
SP.KSD-5	1,154	4,798	6.67	2.56	7.97	0.75	3.31	17.89
SP.KSD-6	228	4,738	6.59	2.55	7.89	0.75	3.30	17.78
SP.KSD-7	288	4,615	6.40	2.54	7.73	0.75	3.29	17.59
SP.KSD-8	213	4,572	6.35	2.53	7.68	0.75	3.28	17.52
SP.KSD-9	256	4,562	6.33	2.53	7.66	0.75	3.28	17.50

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP.KSD-10	931	4,499	6.24	2.52	7.58	0.75	3.27	17.40
SP.KSD-11	615	4,423	6.14	2.52	7.49	0.75	3.27	17.30
SP.KSD-12	515	4,216	5.86	2.50	7.24	0.75	3.25	16.97
SP.KSD-13	900	4,127	5.74	2.49	7.13	0.75	3.24	16.84
SP.KSD-14	1,755	3,916	5.43	2.46	6.84	0.75	3.21	16.45
SP.KSD-15	1,006	3,467	4.82	2.40	6.28	0.60	3.00	15.28
SP.KSD-16	992	3,219	4.47	2.37	5.95	0.60	2.97	14.85
SP.KSD-17	993	3,198	4.44	2.36	5.92	0.60	2.96	14.80
SP.KSD-18	642	3,169	4.40	2.36	5.89	0.60	2.96	14.77
SP.KSD-19	594	3,135	4.35	2.35	5.84	0.60	2.95	14.69

Table 4-77 Urumb 1 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS.URM 1-1	198	240	0.31	0.90	1.16	0.40	1.30	3.76
SS.URM 1-2	197	204	0.26	0.85	1.09	0.40	1.25	3.59
SS.URM 1-3	403	186	0.24	0.83	1.05	0.40	1.23	3.51
SS.URM 1-4	529	139	0.18	0.76	0.95	0.40	1.16	3.27

Table 4-78 Urumb 2 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS.URM 2-1	322	190	0.25	0.84	1.07	0.40	1.24	3.55
SS.URM 2-2	581	93	0.12	0.67	0.82	0.40	1.07	2.96

Table 4-79 Urumb 3 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS.URM 3-1	398	74	0.09	0.60	0.74	0.40	1.00	2.75
SS.URM 3-2	400	38	0.04	0.46	0.56	0.40	0.86	2.28

Table 4-80 Urumb 4 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS.URM 4-1	400	139	0.18	0.76	0.95	0.40	1.16	3.27
SS.URM 4-2	775	103	0.13	0.68	0.83	0.40	1.08	2.99

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS.URM 4-3	146	86	0.11	0.64	0.79	0.40	1.04	2.87
SS.URM 4-4	436	32	0.04	0.46	0.56	0.40	0.86	2.28

Table 4-81 Sidomulyo 1 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS.SML 1-1	1178	103	0.13	0.68	0.84	0.40	1.08	3.00

Table 4-82 Sidomulyo 2 Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS.SML 2-1	785	148	0.19	0.78	0.98	0.40	1.18	3.34
SS.SML 2-2	36	57	0.07	0.56	0.68	0.40	0.96	2.59

4.4.3.7 Kumbe Kampung Canal Dimension

Table 4-83 Kumbe Kampung Secondary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SS KB 1	2663	479	0.632	1.39	1.98	0.50	1.92	5.83
SS KB 2	692	392	0.517	1.31	1.81	0.50	1.84	5.49
SS KB 3	195	318	0.420	1.23	1.66	0.40	1.66	4.97
SS KB 4	194	299	0.395	1.20	1.62	0.40	1.63	4.89
SS KB 5	441	235	0.310	1.12	1.47	0.40	1.54	4.56
SS KB 6	230	206	0.272	1.07	1.40	0.40	1.49	4.39
SS KB 7	448	166	0.219	1.00	1.29	0.40	1.42	4.13
SS KB 8	343	44	0.058	0.64	0.81	0.40	1.07	2.94

4.4.4 Dimensions of conservation/drainage channels for each block of schemes

4.4.4.1 Kurik and Salor Kampung lowland irrigation drainage canal dimensions

Table 4-84 Kurik 1 Drainage Canal Dimension

Name of canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
D. Rawasari 1	D RWS.1-R3	1,035	111	0.67	1.45	1.45	0.50	1.95	7.31
D. Rawasari 1	D RWS.1-R2	696	159	0.92	1.50	1.66	0.50	1.99	7.62
D. Rawasari 1	D RWS.1-R1	1,383	257	1.36	1.64	2.18	0.50	2.14	8.62

Name of canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
D. Rawasari 2	D RWS.2-R3	1,224	97	0.58	1.40	1.34	0.50	1.90	7.04
D. Rawasari 2	D RWS.2-R2	1,077	199	1.11	1.56	1.89	0.50	2.06	8.08
D. Rawasari 2	D RWS.2-R1	1,167	270	1.42	1.66	2.25	0.50	2.16	8.74
D. Rawasari 3	D RWS.3-2	1,342	121	0.72	1.50	1.49	0.50	1.95	7.34
D. Rawasari 3	D RWS.3-1	2,067	218	1.19	1.67	2.09	0.50	2.17	8.60
D. Rawasari 4	D RWS.4-2	1,246	61	0.36	1.22	1.03	0.40	1.62	5.90
D. Rawasari 4	D RWS.4-1	1,073	112	0.67	1.46	1.46	0.50	1.96	7.33
D. Rawasari 5	D RWS.5-1	945	390	1.91	1.78	2.80	0.60	2.38	9.92
D. Kumbe 1	D KMB.1-1	2,231	700	3.04	2.00	4.19	0.60	2.65	14.80
D. Kumbe 2	D KMB.2-2	1,374	431	2.07	1.87	3.08	0.60	2.48	12.98
D. Kumbe 2	D KMB.2-1	1,657	521	2.41	1.94	3.46	0.60	2.54	13.61
D. Kumbe 3	D KMB.3-1	1,727	1,221	4.67	2.10	5.54	0.60	2.70	16.33
D. Kumbe 4	D KMB.4-4	2,714	300	1.55	1.51	2.13	0.60	2.11	8.46
D. Kumbe 4	D KMB.4-3	1,898	481	2.26	1.70	2.94	0.60	2.30	12.15
D. Kumbe 4	D KMB.4-2	1,212	722	3.12	2.00	3.96	0.60	2.51	14.02
D. Kumbe 4	D KMB.4-1	516	1,195	4.60	2.09	5.47	0.60	2.69	16.24
D. Kumbe 5	D KMB.5-1	1,719	181	1.02	1.53	1.79	0.50	2.03	7.89
D. Kumbe 6	D KMB.6-1	1,637	241	1.30	1.62	2.11	0.50	2.12	8.48
D. Kumbe 7	D KMB.7-2	1,311	128	0.76	1.50	1.57	0.50	2.01	7.60
D. Kumbe 7	D KMB.7-1	460	369	1.83	1.76	2.71	0.60	2.36	9.78
D. Kumbe 8	D KMB.8-1	2,148	174	0.99	1.52	1.75	0.50	2.02	7.82
D. Kumbe 9	D KMB.9-1	2,592	103	0.63	1.43	1.40	0.50	1.93	7.18
D. Kaliki 4	D KLK.4-3	1,235	75	0.45	1.30	1.16	0.40	1.70	6.25
D. Kaliki 4	D KLK.4-2	1,725	399	1.95	1.78	2.83	0.60	2.38	9.98
D. Kaliki 4	D KLK.4-1	1,777	531	2.45	1.94	3.51	0.60	2.54	13.68

Table 4-85 Kurik 2 and Salor Kampung Drainage Canal Dimension

Nama of canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
D. Ivimahad 1	D IVM.1-3	2,053	204	1.13	1.98	2.41	0.50	2.48	9.85
D. Ivimahad 1	D IVM.1-2	972	355	1.77	2.09	3.16	0.60	2.69	11.23
D. Ivimahad 1	D IVM.1-1	760	466	2.21	2.28	3.87	0.60	2.88	15.38
D. Ivimahad 2	D IVM.2-2	623	199	1.11	1.97	2.38	0.50	2.47	9.80
D. Ivimahad 2	D IVM.2-1	3,568	631	2.80	2.39	4.66	0.60	2.99	16.64
D. Ivimahad 3	D IVM.3-2	661	343	1.73	2.72	4.05	0.60	3.32	14.00
D. Ivimahad 3	D IVM.3-1	1,590	607	2.72	3.11	5.96	0.60	3.71	20.80
D. Kaliki 1	D KLK.1-1	1,791	203	1.13	2.46	2.99	0.50	2.96	11.86
D. Kaliki 2	D KLK.2-2	922	110	0.68	1.73	1.74	0.50	2.23	8.43
D. Kaliki 2	D KLK.2-1	141	183	1.03	1.94	2.27	0.50	2.44	9.58
D. Kaliki 3	D KLK.3-2	621	16	0.13	1.45	1.05	0.40	1.85	6.60
D. Kaliki 3	D KLK.3-1	544	72	0.47	2.00	1.86	0.40	2.47	9.26
D. Harapan Makmur 1	D HMA.1-1	1,001	362	1.80	2.74	4.19	0.60	3.34	14.22
D. Harapan Makmur 2	D HMA.2-1	1,528	159	0.92	2.33	2.61	0.50	2.83	11.11
D. Harapan Makmur 3	D HMA.3-1	469	1,081	4.26	1.86	4.65	0.60	2.46	14.51
D. Kaliki 5	D KLK.5-3	1,938	110	0.67	1.46	1.46	0.50	1.96	7.33
D. Kaliki 5	D KLK.5-2	1,260	110	0.67	1.46	1.46	0.50	1.96	7.33

Nama of canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
D. Kaliki 5	D KLK.5-1	2,267	367	1.82	1.76	2.70	0.60	2.36	9.77
D. Salor Kampung	D SKG-3	2,414	161	0.93	1.88	2.11	0.50	2.38	9.26
D. Salor Kampung	D SKG-2	405	109	0.67	1.73	1.72	0.50	2.23	8.40
D. Salor Kampung	D SKG-1	205	270	1.42	2.00	2.68	0.50	2.48	10.12

Table 4-86 Kurik 5 & 6 Drainage Canal Dimension

Nama of canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
D. Sumber Mulya 3	D SMA.3-1	1,386	191	1.07	1.55	1.85	0.50	2.05	8.00
D. Sumber Mulya 4	D SMA.4-2	1,909	250	1.34	1.64	2.15	0.50	2.14	8.56
D. Sumber Mulya 4	D SMA.4-1	2,384	727	3.13	2.00	3.98	0.60	2.52	14.05
D. Sumber Mulya 5	D SMA.5-3	1,179	397	1.94	1.78	2.83	0.60	2.38	9.97
D. Sumber Mulya 5	D SMA.5-2	1,849	482	2.27	1.91	3.30	0.60	2.51	13.35
D. Sumber Mulya 5	D SMA.5-1	1,425	1,447	5.32	2.15	6.12	0.75	2.90	17.72
D. Sumber Mulya 6	D SMA.6-3	825	82	0.52	1.50	1.43	0.50	2.04	7.54
D. Sumber Mulya 6	D SMA.6-2	885	128	0.76	1.59	1.67	0.50	2.09	7.95
D. Sumber Mulya 6	D SMA.6-1	1,254	397	1.94	2.00	3.18	0.60	2.60	10.98
D. Sumber Mulya 7	D SMA.7-2	2,364	106	0.65	1.45	1.43	0.50	1.95	7.27
D. Sumber Mulya 7	D SMA.7-1	2,077	213	1.17	1.59	1.96	0.50	2.09	8.22
D. Jaya Makmur 4	D JMK.4-1	2,719	1,621	5.80	2.19	6.54	0.75	2.93	18.27
D. Jaya Makmur 5	D JMK.5-1	1,679	237	1.28	1.82	2.34	0.50	2.32	9.30
D Suka Maju 1	D KMU.1-1	1,271	155	0.90	1.51	1.63	0.50	1.97	7.54
D Suka Maju 2	D KMU.2-1	792	92	2.00	1.86	3.00	0.60	2.46	12.84
D Suka Maju 3	D KMU.3-1	980	394	1.93	1.78	2.81	0.60	2.38	9.95
D Suka Maju 4	D KMU.4-3	1,339	213	1.17	1.59	1.96	0.50	2.09	8.22
D Suka Maju 4	D KMU.4-2	1,363	654	2.88	2.00	4.00	0.60	2.62	14.47
D Suka Maju 4	D KMU.4-1	1,639	849	3.53	2.00	4.43	0.60	2.59	14.77
D Suka Maju 5	D KMU.5-2	1,614	74	0.48	1.33	1.20	0.40	1.73	6.38
D Suka Maju 5	D KMU.5-1	1,893	166	0.95	1.51	1.71	0.50	2.01	7.73
D Suka Maju 6	D KMU.6-2	445	61	0.41	1.26	1.10	0.40	1.67	6.10
D Suka Maju 6	D KMU.6-1	1,105	204	1.13	1.57	1.92	0.50	2.07	8.13
D Suka Maju 7	D KMU.7-3	1,289	150	0.88	1.50	1.60	0.50	1.96	7.48
D Suka Maju 7	D KMU.7-2	1,080	782	3.32	2.00	4.19	0.60	2.55	14.38
D Suka Maju 7	D KMU.7-1	1,758	898	3.69	2.01	4.60	0.60	2.61	15.03
D Suka Maju 8	D KMU.8-2	1,526	929	3.79	2.02	4.69	0.60	2.62	15.16
D Suka Maju 8	D KMU.8-1	1,854	193	1.08	1.55	1.85	0.50	2.05	8.01
D Suka Maju 9	D KMU.9-1	532	1,041	4.14	2.05	5.03	0.60	2.65	15.64

4.4.4.2 Salor lowland irrigation drainage dimensions

Table 4-87 Salor Drainage Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
DP SLR I.1-1	1,085	922	3.77	2.02	4.68	0.60	2.62	12.54
DP SLR I.2-3	830	450	2.15	2.26	3.79	0.60	2.86	12.37
DP SLR I.2-2	1,313	1,387	5.15	2.69	7.53	0.75	3.44	17.85
DP SLR I.2-1	487	4,306	11.91	2.52	10.80	1.00	3.52	21.36
DP SLR II-4	250	330	1.67	2.06	3.03	0.6	2.66	11.01
DP SLR II-3	280	787	3.33	2.48	5.35	0.6	3.08	14.59
DP SLR II-2	501	1129	4.4	2.62	6.66	0.6	3.22	16.32
DP SLR II-1	507	1997	6.78	2.83	9.27	0.75	3.58	20.01

4.4.4.3 Lower Jagebob canal drainage dimension

Table 4-88 Jagebob Raya Drainage Canal Dimension

Drain Canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
DP Jagebob Raya -1	DP JGR -1	1222	1630	5.82	2.19	6.56	0.75	2.94	18.30
DS Jagebob Raya 2	DS JGR 2	2,130	370	1.84	1.51	2.33	0.60	2.11	8.66
DS Jagebob Raya 3	DS JGR 3	1,300	190	1.07	1.41	1.68	0.50	1.91	7.42
DP Jagebob Raya -2	DP JGR -2	2,990	720	3.11	1.91	3.96	0.60	2.51	14.00
DS Jagebob Raya 1	DS JGR 1	640	180	1.02	1.40	1.63	0.50	1.90	7.32

Table 4-89 Kamnosari Drainage Canal Dimension

Drain Canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
DP Kamnosari 1	DP KMS 1	2,580	700	3.04	1.90	3.88	0.60	2.50	13.89
DS Kamnosari 1	DS KMS 1	1,500	390	1.91	1.52	2.40	0.60	2.12	8.77
DP Gurinda Jaya	DP GRJ	1,222	1,080	4.26	2.06	5.15	0.60	2.66	15.80
DS Gurinda Jaya	DS GRJ	2,130	800	3.38	1.78	3.87	0.60	2.38	13.40
DP Kamnosari 2	DP KMS 2	1,580	1,220	4.67	2.10	5.54	0.60	2.70	16.33
DS Kamnosari 2	DS KMS 2	2,150	300	1.55	1.57	2.22	0.60	2.17	8.72
DS Mimi Baru 3-1	DS MMB 3-1	2,300	725	3.13	1.91	3.98	0.60	2.51	14.03
DS Mimi Baru 3-2	DS MMB 3-2	1,500	300	1.55	1.39	1.96	0.60	1.99	7.93

Table 4-90 Mimi Baru Drainage Canal Dimension

Drain Canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
DP Mimi Baru 1	DP MMB 1	1,920	2259	7.43	2.14	7.35	0.75	2.89	18.91
DS Mimi Baru 1-1	DS MMB 1-1	2,960	1222	4.68	1.90	5.01	0.60	2.50	15.00

Drain Canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
DS Mimi Baru 1-2	DS MMB 1-2	800	240	1.29	1.48	1.92	0.50	1.98	7.86
DS Jagebob Raya 4	DS JGR 4	3,600	407	1.98	1.54	2.46	0.60	2.14	8.87
DS Jagebob Raya 5-1	DS JGR 5-2	2,360	657	2.90	1.73	3.43	0.60	2.33	12.74
DS Jagebob Raya 5-2	DS JGR 5-2	2,740	440	2.11	1.62	2.68	0.60	2.22	11.54
DP Mimi Baru 2	DP MMB 2	360	400	1.95	1.78	2.84	0.60	2.38	9.99
DS Mimi Baru 2-1	DS MMB 2-1	600	150	0.88	1.34	1.48	0.50	1.84	7.00
DS Mimi Baru 2-2	DS MMb 2-2	960	180	1.02	1.53	1.79	0.50	2.03	7.88

4.4.4.4 Sermayam New Lowland Irrigation Drainage Canal Dimension

Table 4-91 Sermayam New Drainage Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP SRM 1	2,204	847	3.53	2.23	4.98	0.60	2.83	16.32
SP SRM 2	3,446	658	2.90	2.15	4.27	0.60	2.75	15.26
SS KMG 1.1	4,789	885	3.65	2.25	5.12	0.60	2.85	16.51
SS KMG 1.2	2,717	776	3.30	2.20	4.72	0.60	2.80	15.94
SS KMG 2.1	6,209	1,226	4.69	2.36	6.23	0.60	2.96	18.06
SS KMG 2.2	3,783	455	2.17	2.02	3.40	0.60	2.62	13.87
SS KMG 2.3	2,044	48	0.33	1.33	1.11	0.40	1.73	6.31
SS TMB 1	4,426	155	0.90	1.66	1.85	0.50	2.16	8.34

4.4.4.5 Tanah Miring lowland irrigation drainage canal dimensions

Table 4-92 Tanah Miring Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM 1	1,225	1,887	13.32	2.73	12.90	1.00	3.73	27.81
SP TM 2	462	1,817	12.80	2.71	12.50	1.00	3.71	27.35
SP TM 3	340	1,207	8.28	2.45	8.67	0.75	3.20	18.29
SP TM 4	35	969	6.56	2.36	7.27	0.75	3.10	16.58

Table 4-93 Tanah Miring SP9 1 Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM9	686	2,027	14.38	2.76	13.68	1.00	3.76	28.72
SP TM9 1.1	2,415	1,199	8.22	2.45	8.63	0.75	3.20	18.23
SP TM9 1.2	405	1,144	7.82	2.43	8.30	0.75	3.18	17.84
SP TM9 1.3	405	1,087	7.41	2.41	7.97	0.75	3.16	17.44
SP TM9 1.4	1,783	1,061	7.22	2.40	7.81	0.75	3.15	17.25
SP TM9 1.5	425	1,033	7.02	2.38	7.65	0.75	3.13	17.05

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM9 1.6	680	1,008	6.84	2.37	7.50	0.75	3.12	16.87
SP TM9 1.7	1,136	701	4.65	2.20	5.65	0.60	2.80	14.06
SP TM9 1.8	1,365	470	3.04	2.01	4.23	0.60	2.61	12.06

Table 4-94 Tanah Miring SP9 2 Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM9 2.1	1,437	467	3.02	2.00	4.22	0.60	2.60	12.03
SP TM9 2.2	395	445	2.86	1.98	4.08	0.60	2.58	11.82
SP TM9 2.3	429	415	2.66	1.95	3.89	0.60	2.55	11.53
SP TM9 2.4	707	374	2.38	1.89	3.63	0.60	2.49	11.12

Table 4-95 Tanah Miring SP9 3 Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM9 3.1	3,285	693	4.59	2.20	5.60	0.60	2.80	14.00
SP TM9 3.2	534	640	4.22	2.16	5.28	0.60	2.76	13.56
SP TM9 3.3	288	487	3.15	2.03	4.34	0.60	2.63	12.21
SP TM9 3.4	548	419	2.69	1.95	3.91	0.60	2.55	11.57
SP TM9 3.5	337	367	2.33	1.89	3.59	0.60	2.48	11.04
SP TM9 3.6	413	331	2.09	1.83	3.36	0.60	2.43	10.66
SP TM9 3.7	399	284	1.78	1.76	3.05	0.60	2.36	10.13
SP TM9 3.8	253	236	1.46	1.62	2.67	0.50	2.12	6.92
SP TM9 3.9	488	212	1.30	1.58	2.51	0.50	2.08	6.66
SP TM9 3.10	401	163	0.98	1.49	2.23	0.50	1.99	6.20
SP TM9 3.11	307	113	0.68	1.33	1.87	0.50	1.83	5.54
SP TM9 3.12	426	72	0.43	1.16	1.54	0.40	1.56	4.67
SP TM9 3.13	136	24	0.14	0.82	1.02	0.40	1.22	3.45

Table 4-96 Tanah Miring SP2 Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM2 1	3,267	658	4.34	2.17	5.39	0.60	2.77	13.71
SP TM2 2	215	640	4.22	2.16	5.28	0.60	2.76	13.56
SP TM2 3	414	580	3.80	2.11	4.91	0.60	2.71	13.05
SP TM2 4	380	517	3.36	2.06	4.53	0.60	2.66	12.49
SP TM2 5	161	485	3.14	2.02	4.33	0.60	2.62	12.20
SP TM2 6	283	437	2.81	1.97	4.03	0.60	2.57	11.74
SP TM2 7	381	404	2.58	1.93	3.82	0.60	2.53	11.42
SP TM2 8	424	339	2.14	1.85	3.41	0.60	2.45	10.74
SP TM2 9	204	266	1.66	1.73	2.94	0.60	2.33	9.91
SP TM2 10	508	150	0.90	1.45	2.13	0.50	1.95	6.03

Table 4-97 Tanah Miring SP4 1 Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM4 1.1	1,400	274	1.71	1.74	2.99	0.60	2.34	10.01
SP TM4 1.2	2,102	256	1.59	1.71	2.87	0.60	2.31	9.79
SP TM4 2.1	120	664	4.39	2.18	5.43	0.60	2.78	13.76
SP TM4 2.2	405	608	3.99	2.13	5.09	0.60	2.73	13.29
SP TM4 2.3	108	570	3.73	2.10	4.85	0.60	2.70	12.96
SP TM4 2.4	287	274	1.71	1.74	2.99	0.60	2.34	10.01
SP TM4 2.5	506	239	1.48	1.63	2.69	0.50	2.13	6.95
SP TM4 2.6	1,343	215	1.32	1.58	2.53	0.50	2.08	6.69
SP TM4 2.7	544	135	0.81	1.41	2.03	0.50	1.91	5.84
SP TM4 2.8	1,145	90	0.54	1.24	1.70	0.50	1.75	5.19

Table 4-98 Tanah Miring SP7 1 Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM7 1.1	778	610	4.01	2.14	5.10	0.60	2.74	13.31
SP TM7 1.2	390	570	3.73	2.10	4.85	0.60	2.70	12.96
SP TM7 1.3	486	538	3.51	2.07	4.66	0.60	2.67	12.68
SP TM7 1.4	600	502	3.26	2.04	4.43	0.60	2.64	12.35
SP TM7 1.5	184	447	2.88	1.98	4.09	0.60	2.58	11.84
SP TM7 1.6	313	405	2.59	1.93	3.83	0.60	2.53	11.43
SP TM7 1.7	407	359	2.28	1.87	3.54	0.60	2.47	10.96
SP TM7 1.8	2,364	323	2.04	1.82	3.31	0.60	2.42	10.57
SP TM7 1.9	185	197	1.20	1.54	2.41	0.50	2.04	6.50
SP TM7 1.10	381	131	0.79	1.39	2.00	0.50	1.89	5.79
SP TM7 1.11	425	94	0.56	1.26	1.73	0.50	1.76	5.25

Table 4-99 Tanah Miring SP7 2 Primary Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
SP TM7 2.1	817	497	3.22	2.04	4.40	0.60	2.64	12.31
SP TM7 2.2	136	466	3.01	2.00	4.21	0.60	2.60	12.02
SP TM7 2.3	566	378	2.41	1.90	3.66	0.60	2.50	11.16
SP TM7 2.4	1,273	330	2.08	1.83	3.35	0.60	2.43	10.65
SP TM7 2.5	1,033	306	1.92	1.79	3.20	0.60	2.39	10.38
SP TM7 2.6	791	279	1.74	1.75	3.02	0.60	2.35	10.07
SP TM7 2.7	350	258	1.60	1.71	2.88	0.60	2.31	9.82
SP TM7 2.8	554	202	1.24	1.55	2.45	0.50	2.05	6.55
SP TM7 2.9	400	160	0.96	1.48	2.21	0.50	1.98	6.16

4.4.4.6 Kuprik Sidomulyo lowland irrigation drainage canal dimensions

Table 4-100 Kuprik Sidomulyo Drainage Canal Dimension

Drain Canal	Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
DP Urumb	DP URM -1	1355	464	2.20	1.90	3.23	0.60	2.50	13.22
DS Urumb 4	DS URM 4	488	243	1.30	1.92	2.50	0.50	2.42	9.77
DP Urumb	DP URM -2	1,996	576	2.61	1.98	3.70	0.60	2.58	14.03
DS Urumb 3	DS URM 3	1,216	142	0.84	1.43	1.55	0.50	1.93	7.34
DP Urumb	DP URM -3	1,510	199	1.11	1.56	1.89	0.50	2.06	8.08
DS Urumb 1	DS URM 1	1,244	111	0.68	1.25	1.26	0.50	1.75	6.52
DS Urumb 2	DS URM 2	1,286	81	0.52	1.35	1.25	0.50	1.85	6.81
DP Sidomulyo	DP SML	466	314	1.61	1.40	2.01	0.60	2.00	8.01
DS Sidomulyo 1	DS SML 1-1	1,942	223	1.21	1.60	2.01	0.50	2.10	8.31
DS Sidomulyo 1	DS SML 1-2	2,430	127	0.76	1.52	1.59	0.50	2.02	7.65
DP Kuprik	DP KPR -1	3,504	1,665	5.91	2.46	7.46	0.75	3.21	20.30
DS Kuprik	DS KPR	1,503	227	1.24	1.61	2.04	0.50	2.11	8.37
DS Sidomulyo 2	DS SML 2	391	138	0.81	1.56	1.67	0.50	2.06	7.84
DP Kuprik	DP KPR -2	3,952	1,130	4.41	2.33	5.94	0.60	2.93	17.66
DS Urumb 7	DS URM 7	1,803	264	1.40	1.63	2.19	0.50	2.13	8.58
DP Kuprik	DP KPR -3	3,999	500	2.33	2.05	3.60	0.60	2.65	14.21
DS Urumb 6	DS URM 6	804	101	0.63	1.45	1.41	0.50	1.95	7.25
DS Urumb 5	DS URM 5	404	51	0.35	1.35	1.14	0.40	1.75	6.40

4.4.4.7 Kumbe Kampung lowland irrigation drainage canal dimensions

Table 4-101 Kumbe Kampung Drainage Canal Dimension

Section	Length (m)	Service area (ha)	Discharge (m3/sec)	h water level (m)	bottom width (m)	Free board (m)	H tot (m)	Top width (m)
DP KBK	1066	479	1.75	1.70	2.93	0.60	2.30	12.14
DS KBK-1	4195	349	0.78	1.55	2.33	0.60	2.15	8.79
DS KBK-2	3608	130	2.26	1.35	1.42	0.50	1.85	6.97

4.5 Pump station design

Lowland irrigation areas in Merauke are always higher than the normal high tide levels in the adjacent river, even during the wet season. When the crops require additional water to mature, flows need to be delivered to the field by pumping. There are two types of pumping that have been incorporated in the design. The first is the pumping in the supply system, to lift water from the primary canals to the secondaries that would be under the responsibility of the irrigation operator. This service is an additional water on top of the water delivery by the farmer and is designed to ensure sufficient water penetrates the secondary canals. Normally it needs about 3-4 m of water level lifting. The operator has the flexibility of:

a. providing all of the pumping to the full supply levels in all of the canals which is practical if all fields are at the same or very similar levels so that farmer pumping is not necessary;

b. providing pumping to some of the lower area canal FSWL's but farmers in higher areas will have to pump from lower order canals.

c. The operator pumping to a certain level and the farmers pumping from that level which is either topped up every morning or after several days when the level in the canals have reached a critical lower level. This is the situation modelled by HECRAS on several schemes.

The second is irrigation water pumping by farmer from the drainage /conservation canals to the field using their own pumps once the stoplogs have been inserted into the outlet structures. This is under the responsibility of farmers individually or as a group. This kind of pumping is to augment the main system pumping especially in the dry season when the river flows are either too low or too saline. If such water is available it should be used in preference to the pumped river water as it will be at a higher level. In some situations it may be possible to blend drainage water with brackish river water to maintain concentrations to those that do not affect crop production.

4.5.1 Pump station in the supply system

Pumping station planning follows the irrigation design provisions concerning the most basic things in the pumping station design process, these include: (i) Location of pump station, (ii) topographic conditions and (iii) the design level of water service. (iv) the power to be used to operate the pumps and (v) the target daily period of pumping.

The capacity of the pumps and pump station, including the power to operate the pumps, is calculated based on the (i) design discharge, (ii) total water lift, (iii) the estimated loss of flow and energy and (iv) the target operating period.

The capacity will depend on the daily operating period. Initially this considered as 8 hours but for just two monthly periods this gave very high capacities that would not be efficiently used during the remainder of the year. Consequently, the canal and pump station capacities are based on a 12 hour pumping schedule for two months and 8 hours during the rest of the year. When the capacity has been decided, the number of pumps should be decided. To provide the flexibility of pumping service, the number of pumps in one station should have 2 unit or more. In larger stations this could include a spare. In much smaller stations a single pump might be acceptable if spare pumps are kept at the maintenance facility, especially if there are multiple small pump stations for tertiary areas. There are two types of electric pumps to be used: submerged centrifugal pumps – normally for low flows, and submerged axial pumps – for higher flows.

The station has been designed in typical form, based on the design discharge. The pump station must be easy to access, easy to operate and to maintain, and the pump and associated mechanical and electrical spare-parts easy to locate and quickly order if not in a central storeroom. The power source, initially a generator for larger pump stations and solar panels as trials on the few smaller stations. Along with the operating and monitoring panels, they should be housed within the secure pump station.

As the pumps may have to deal with the acidic and brackish water, the material of the pump unit should be guaranteed in such environments.

Table 4-102 Specification for pump main component

Descriptions	Material	Application
Impeller	Phosphor Bronze (PBC)	Sea Water
Shaft	Stainless Steel (SUS 304)	Sea Water
Sleeve/Coupling	Stainless Steel (SUS 304)	Sea Water
Casing	Gray Cast Iron (FC20~25)	Water, Rainwater and sea water

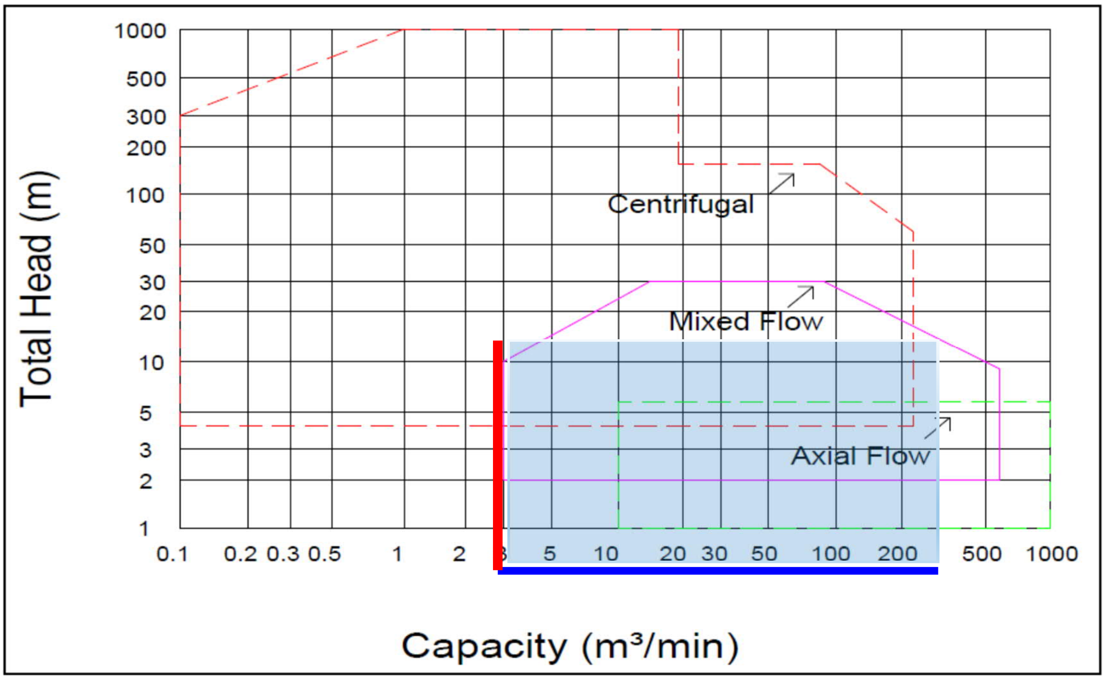
The pump stations are categorised into a ranges of sizes to simplify design and ensure some uniformity in types of pump and spare parts. **Table 4-103** provides 5 types of the range of pumps, capacities and pump types. A temporary emergency pump station is shown as a possibility for some of the Kumbe lowland schemes that could be irrigated by gravity should the Kumbe Dam FS during the early part of Phase 2 prove to have high economic indicators.

Table 4-103 Pump Station Grouping

Group	Capacity	Pump type
Large pump station	More than 5000 Litre/sec	Axial Mix flow
Medium pump station	100 ~ 5000 Litre/sec	Axial Submersible
Small pump station	20 ~ 100 Litre/sec	Centrifugal Submersible
Temporary/emergency pump station	25 ~ 250 Litre/sec	Centrifugal With trailer
Pilot/farmer' pump station	10 ~ 50 Litre/sec	Centrifugal Submersible

From the capacity that has been obtained, the selection of the type of pump can be seen simply by using a monogram table.

Figure 4-1 Pump Type Selection Chart



The monogram will show the pump capacity that can be selected based on the capacity of the pump unit. the average capacity of the pump units in the Merauke irrigation system (MIS) canal ranges from 20 up to 1000 l/s or 1.2 m^3/min up to 60 m^3/min and the average head ranges from 1m to 15m as shown by the red line in the diagram.

From the two lines, an area is obtained that shows the capacity and types of pumps that can be applied. as shown by the green block in the diagram. From the results of the selection of the types of pumps, they are grouped by capacity into:

- Pump Capacity 20 l/s to 200 l/s - Centrifugal type pump Group
- Pump Capacity 200 l/s to 1000 l/s – Mixed flow type pump Group
- Pump Capacity 1000 l/s to 10000 l/s -Axial Flow type pump Group

The grouping of these types of pumps is based on how the pump works. but in reality, we also have to choose the type of pump based on its construction and use so that the pump we choose is really precise and efficient.

Based on construction and conditions of use. The grouping of the types of pumps is:

- Pump Capacity 20 l/s to 100 l/s - **submerged centrifugal but also called a sub. drain pump** - for pilot area and collector area.
- Pump Capacity 20 l/s to 200 l/s - s**ub. drain pump** - for secondary pump
- Pump Capacity 200 l/s to 1000 l/s - **Axial Submersible Pump** - for Primary/Secondary Pump
- Pump Capacity 1000 l/s to 10000 l/s - **Axial Mix flow Pump** - for Large Pump Station

The pump selection steps are carried out on each pump house design that has been determined in the irrigation design.

Pump station design follows the existing design criteria and planning standards recommended by the manufacturer or related association. The pump station has several typical designs that are individually modified to suit the particular pump station design parameters and applied throughout the Merauke irrigation system (MIS). In terms of the hydro-mechanical aspects, the planning of a pump station includes the standard distances of the pump in relation to the civil works: intake, pump well and pump station upper building and outlet. It includes the supporting equipment such as stoplog grooves and application, trash rack, travelling lifting gantry, diesel power generator and electrical components set out in a wiring diagram.

4.5.2 Power station for pumps

The pump station planning follows the irrigation design provisions concerning the most basic things in the pumping station design process, these include: (i) Location of pump station, (ii) topographic conditions and (iii) the design level of water service. (iv) power will be used to operate the pumps.

The selection of the type of generator and the planning of its operating system depends on (i) the power required for each station, (ii) the type of power will be used (by PLN or diesel engine generator, of solar electricity), (iii) control system of the power system.

The power generation of pump stations has also been categorised to assist the designers. The identification aims to facilitate information regarding the amount of electrical power generated to meet the needs in the irrigation system so that it can be known how efficiently the generating station is planned, and how much it costs to operate and maintain it.

Table 4-104 Power station grouping

Group	Type	Service
Self-powered generator	Solar cell	Lightening Area, pilot pump station and collector area pump station.
Genset house	Diesel Engine	Small Pump Station Emergency Pump Station
Medium power station	Diesel Power station	Small Pump Station Emergency Pump Station Collector Pump Station
Large power station	Diesel Power Plant	Large Pump Station Weir Gates Large Intake Facility

4.6 Irrigation canal modelling

4.6.1 General

The hydraulic modelling was carried out using HEC-RAS 6.1. In this model, the irrigation network will be modelled from the intake to primary and secondary channel and then water will be pumped by the farmer to the collector canal. The modelled in this report includes: Salor, Kurik, Tanah Miring and Serapu. Each intake in the irrigation area is influenced by tides except for the Kurik intake which is the most upstream. Each intake will be designed with flap gates, where at high tide the river water will enter the canal, but as the tide recedes and drops below the canal level the gates automatically close to prevent loss of water. The capacity of the channel and the volume of water entering the channel must be able to supply each collector irrigation channel.

The main pump station at the start of the secondary canal operates for 8 hours with a pumping discharge of 2-3 times the required discharge (because the pump only works 1/3 day). However, at low tide there is no water entering the channel, therefore hydraulic modelling is needed due to the dynamic changes in supply to determine the reliability of the channel capacity, as the channel only gets supply during the high tide cycle. In addition, the modelling examines the reliability of each pump, and the elevation of the water level in the channel before and after the pump. The secondary canal fills the secondary and collector canals to a set level. The farmers pump from this level for several days until the water reaches a critical low level that will cause the main pump station to refill the canals.

4.6.2 Summary of canal modelling

A summary and detailed description of the modelling exercise on the Phase 1 lowland schemes is given here.

Kurik Scheme: Tidal variation at the main Kurik Intake is only 0.20 m and in the dry season varies between 2 and 2,2m. The main system provides gravity flow based on the flow entering the main intake structure with this variation. The analysis shows that for most Kurik schemes there is sufficient storage in the proposed Main Canal system to allow 8 hours pumping to service all collector systems. The exception is Kurik 2 which relies on an intake downstream more significantly affected by tidal variation. Modelling of the proposed intake and canal improvements shows that they are sufficient to transmit water entering during the high tide cycle to satisfy collector demands.

Salor 1: Modelling of the existing Salor 1 system showed that one secondary canal through an inhabited area could not transmit flows through it. With an improved intake and deeper canals through this reach the main canal could maintain levels between 1.18 mOD to 1.43 mOD to allow secondary pumping to higher levels and confirm collector demands were satisfied. It also suggested that under one operational scenario that pumping might only be needed every 5 days with the secondary pump station providing sufficient water levels on day 1 with the following 4 days requiring farmer pumping as shown on **Figure 4-7**.

Tanah Miring 2,4, 7 and 9: Modelling showed that during spring tides the levels in the canals reached a level of 1.37 m and dropped to elevation 1.15 after pumping. However, in the neap tide cycle the level rose to 1.18m and dropped to about 1.10m after pumping. The secondary level pumps were able to maintain a consistent level in the secondary canals between 0.80 mOD and 1.50 mOD to provide farmers with an adequate supply to pump from.

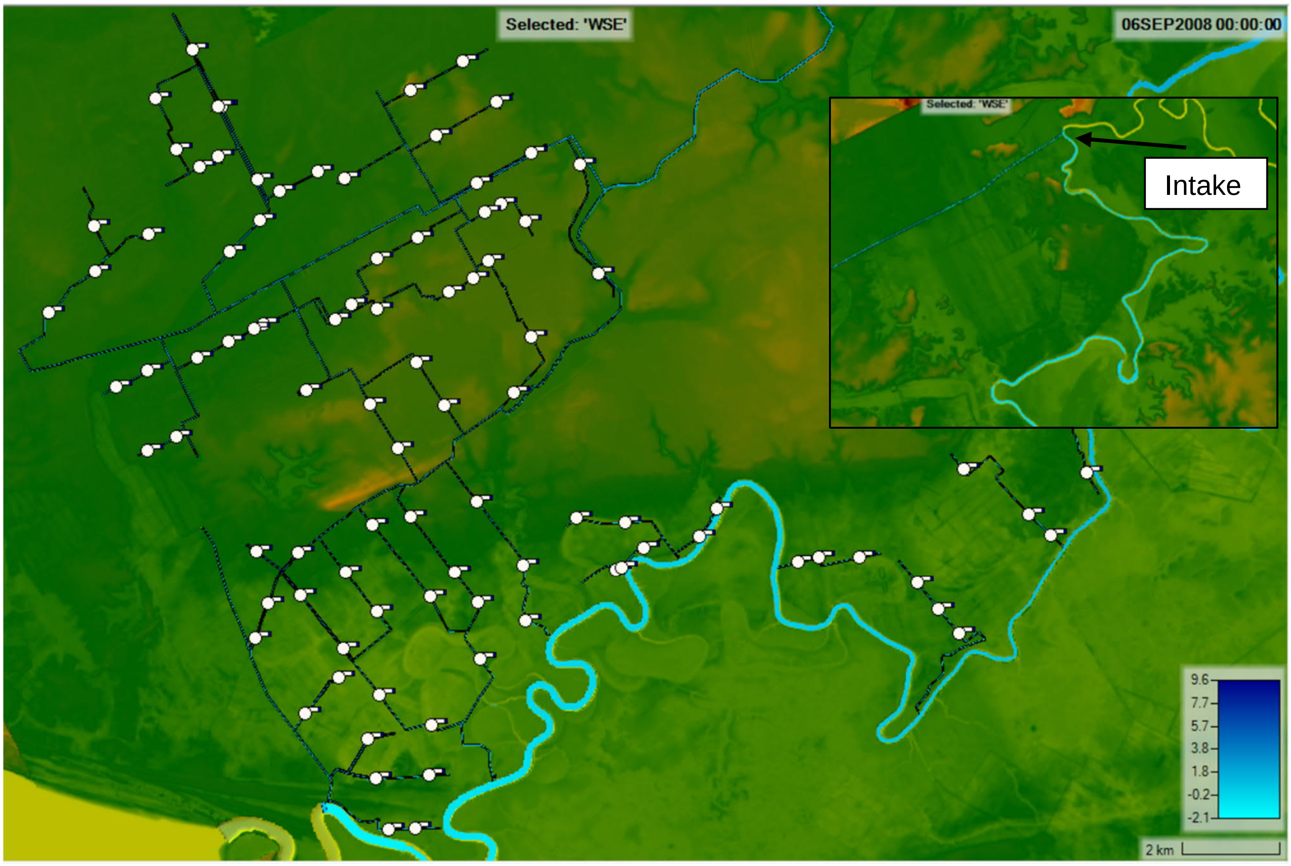
Kuprik Sidomulyo: The intake for Kuprik Sidomulyo irrigation area is located 22 km upstream from the estuary mouth of the Maro river so that the water in the intake is significantly affected by tides. Owing to the location between two seas the tides are complex. Water can only intermittently enter the intake of the primary canal depending on the tidal cycle. From this primary channel water will then be pumped into secondary channels. It appears that at each high tide water can be pumped into the secondary channels to a consistent depth of 1.5mOD but the retained level drops throughout the tidal cycle from about 0.7 mOD to -0.2 mOD. It is noted that the scheme also has a problem with salinity during the later dry season.

An auxiliary canal bringing excess water and drainage from the Semangga subprojects would be used at this time and to augment times when intake and pumped levels are low.

4.6.3 Kurik irrigation canal modelling

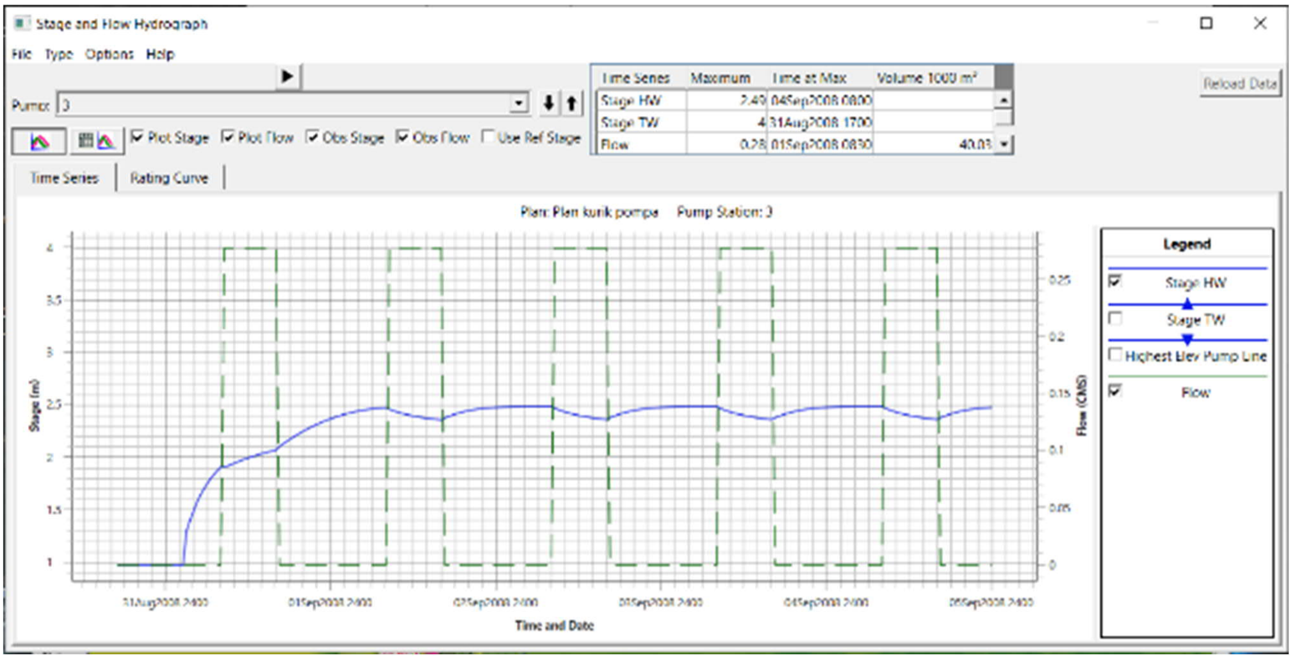
The hydraulic modelling of the Kurik irrigation area includes Kurik 1,2,3,4,5 and 6. The intake is located in the upstream of the Kumbe river (80 km from the downstream) so that the water in the intake is not affected by tides and can enter the primary channel of the Kurik-Salor 1 continuously by gravity. From this primary channel will then be divided into 2 primary channels. Primary Kurik Channel 1 as a supply for Kurik 1 and 2. And Primary Kurik Channel 2 which will supply DI Kurik 5, 6, 3 and 4. Each of these primary channels will be directly connected to the drainage/supply channel which is also a drainage cum storage channel to augment the flows. From the primary channel to the drainage channel, the water will flow by gravity. Farmers will directly pump water from this channel to their collector canal, for detail can be seen at figure below.

Figure 4-2 Kurik modelling scheme



In this drainage cum storage channel, farmers will pump directly to supply their collector canal. Farmer's individual pumps will operate for 8 hours, from 8 am to 4 pm, and will be set like this in HEC-RAS model. The operating pattern of the pump and the water level before and after being pumped can be seen in the figure below. **Figure 4-3** is an example of pumps being modelled.

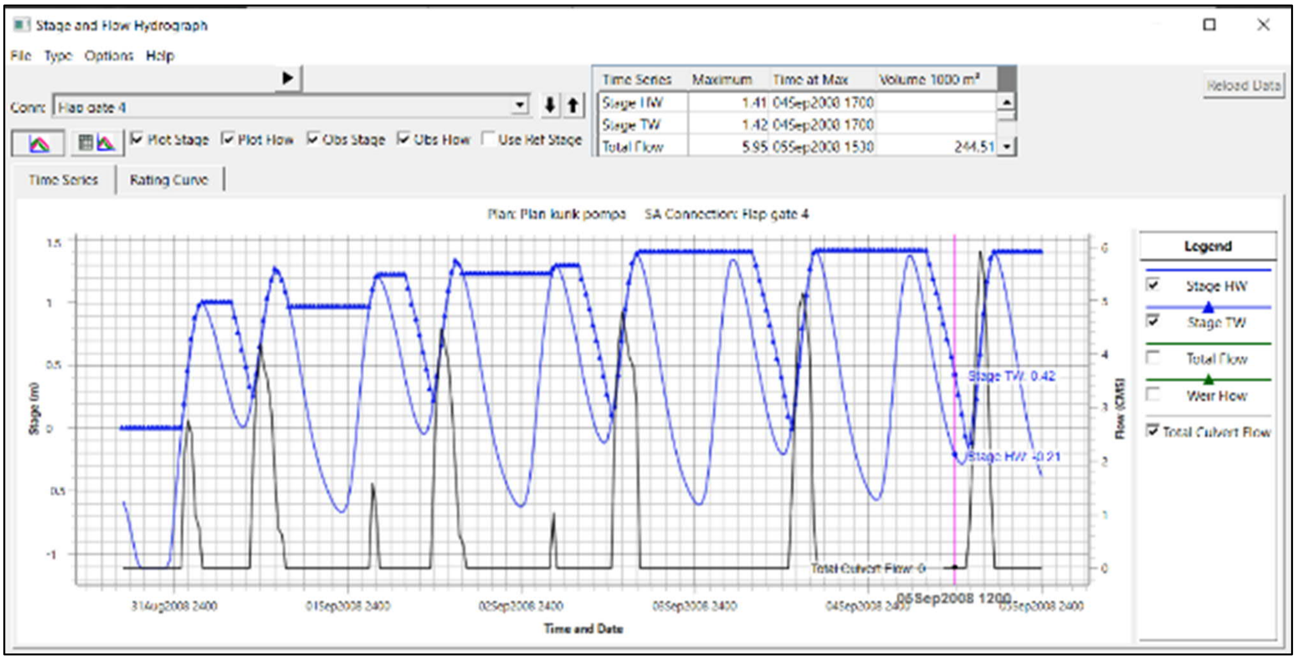
Figure 4-3 Kurik pump modelling



There are several channels that do not have access to the primary channel of Kurik 1 or the primary channel of Kurik 2, this condition occurs in Kurik 2 Irrigation Area. Kurik 2 irrigation area is next to the Kumbe River, so that this channel will receive water directly from the Kumbe River.

The condition of the Kumbe river next to Kurik 2 is still influenced by the tides, so the flap gates are designed in the modelling, where only positive currents can enter the channel (high tide). In the modelling, 6 flap gates are modelled for Kurik 2 Irrigation Area and will be supplied directly from the Kumbe river. The water level and discharge can be seen at each flap gate, an example can be seen in **Figure 4-4**. It can be seen from the figure, that at low tide there is no discharge enters the channel, while at high tide the water will enter the channel.

Figure 4-4 Kurik flap gate modelling



Based on the modelling results, water from the upstream Kurik intake can flow by gravity to the end of collector channel with sufficient discharge. This can be proven by the result of the pump's graph which is working well from 8 am to 5 pm.

In addition, the channel that directly take water from the middle side of Kumbe river (right side of Kurik 2), which is still influenced by the tides, is sufficient to meet the needs of the collector land until the end of channel. The dimensions of the channel and discharge that only rely on incoming tides are sufficient to supply the collector land.

4.6.4 Salor irrigation canal modelling

Salor 1 is adjacent to the Kumbe River and has an adjacent intake with a short (60m) main canal before it branches into two canals that supply the 1532 ha area including the *kebun* and *pekarangan* around the settlements proposed for PMI. At present the irrigation requires additional pumping during both wet and dry seasons. The satellite image infers that the area is cropped twice a year with rice and the soils are well drained.

The intake for Salor uses flap gates and sluice gates to regulate the water level in the main channel. The flap gate will automatically open if the river water level is higher than the water level in the channel, and automatically close if the water level in the river is lower than the water level in the channel. When water salinity in the river exceed safe level for crops, the intake should be closed using a slide gate.

Figure 4-5 Salor system geometric data

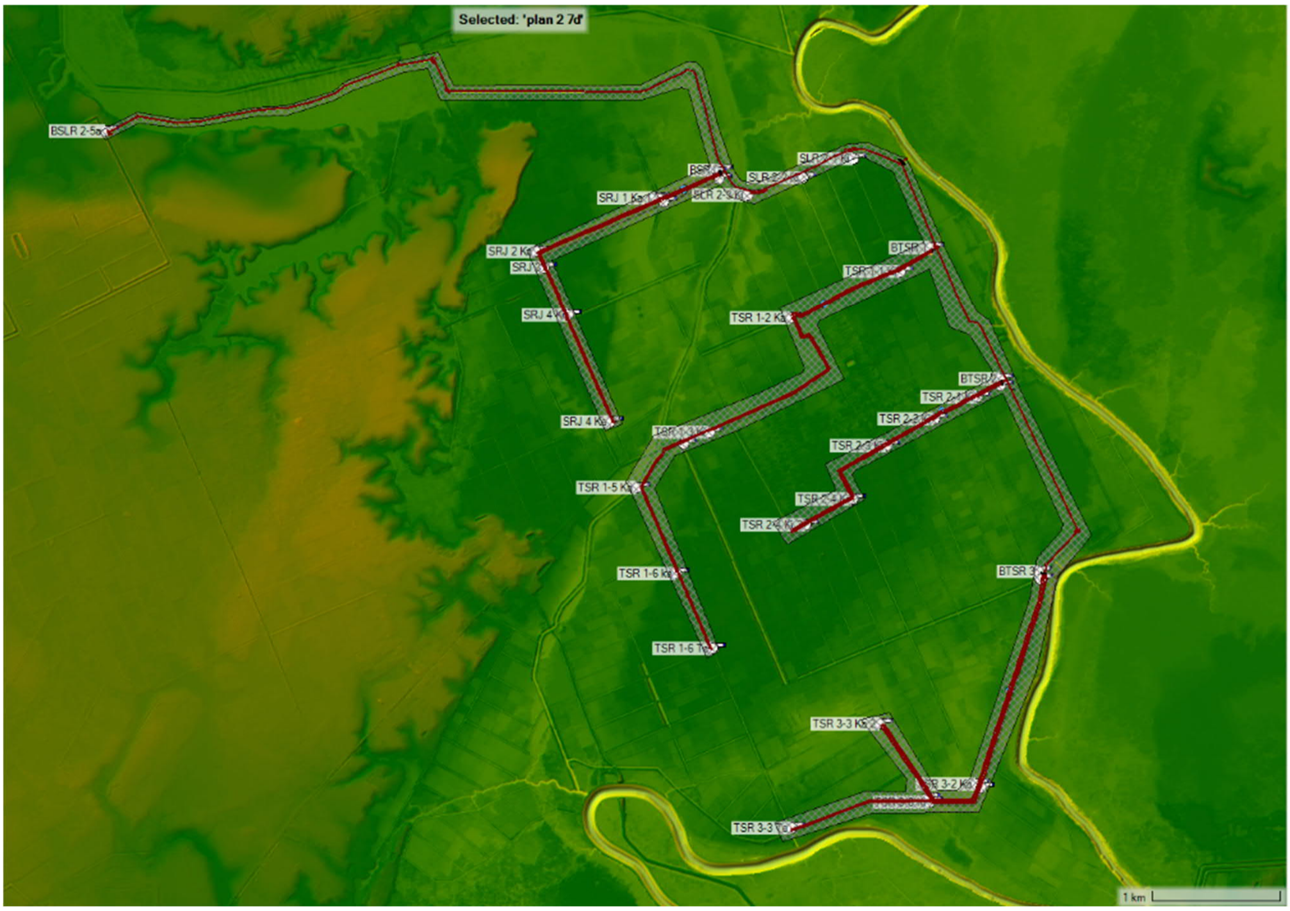
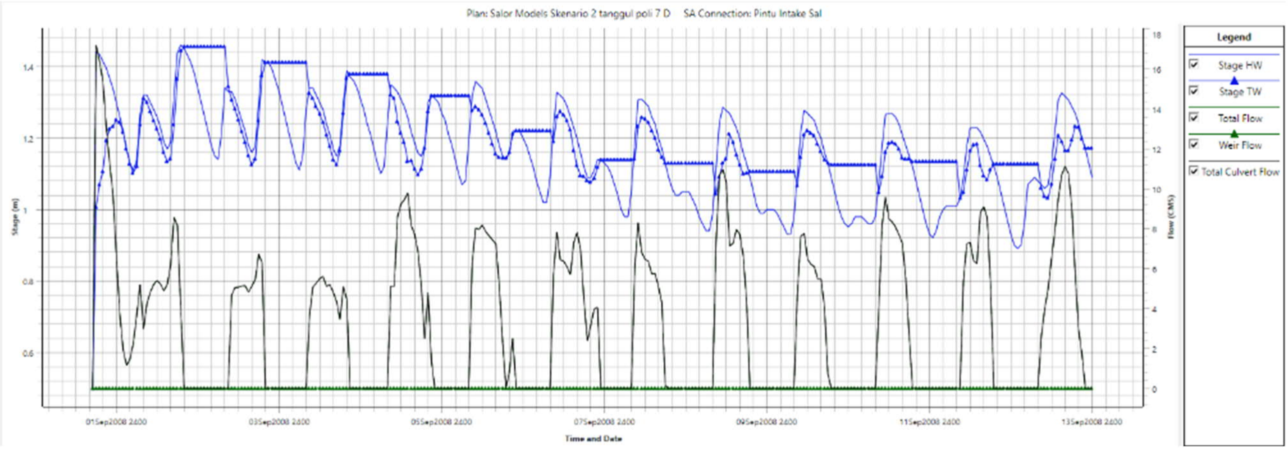
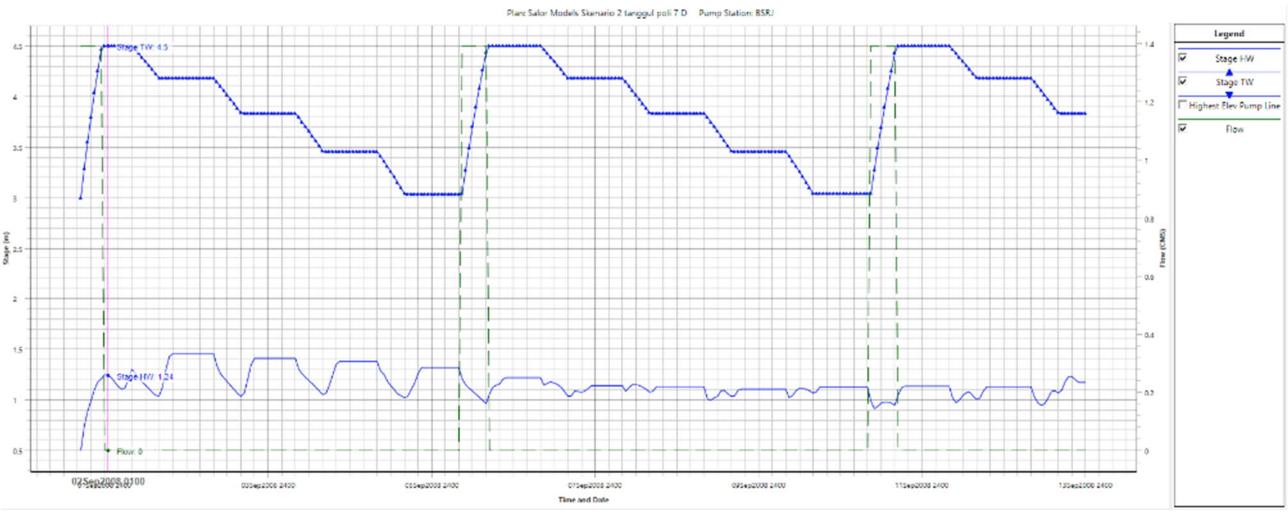


Figure 4-6 Salor intake flow result



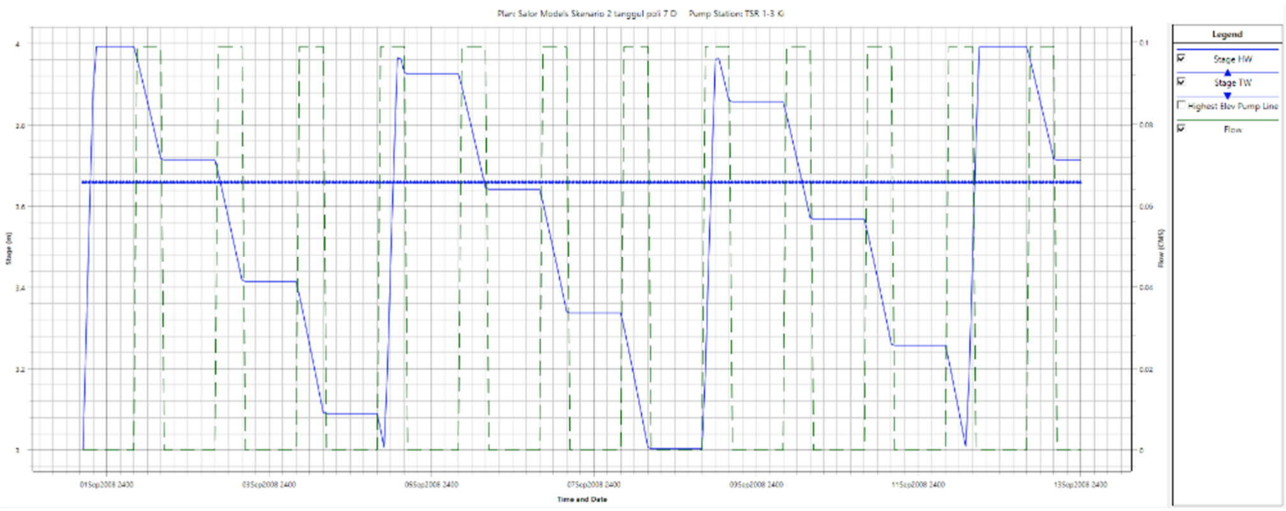
The secondary channel pump station serves to fill the secondary channel to a certain elevation so that farmers can take water more easily. From the model results, the pump only needs to work for 3 days in a period of 2 weeks with the pump operating time for 8 hours in 1 day. The secondary pump operation is shown on **Figure 4-7**.

Figure 4-7 BSRJ secondary pump operation



The collector pumps are set to operate every day for 8 hours according to the net field requirements.

Figure 4-8 TSR 1-3 Ki collector pump operation



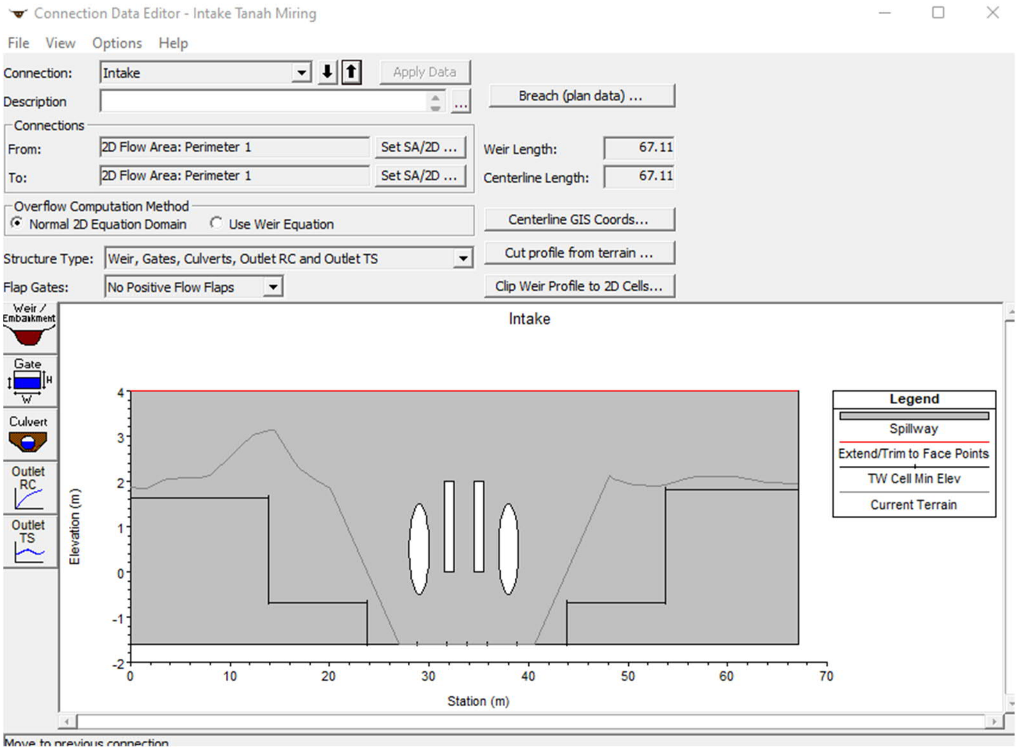
4.6.5 Tanah Miring irrigation canal modelling

Tanah Miring irrigation system uses a drainage cum storage system to supply irrigation in TM SP 2,4,7, and 9. By utilizing existing channels and long storage, the storage formed is used to supply irrigation in augmented operation. The intake structure uses 2 slide gates with a width of 1 meter and 2 flap gates. During supply conditions, the flap gates will open if the river water level is higher than the channel water level. However, the flap gates will be closed if the water level of the channel is higher than the river water level so that water conservation in the channel is maintained. For major flood conditions, the sluice gate will operate as a drain from the channel to the river and the entire channel will function as a drainage channel.

Figure 4-9 Tanah Miring SP9 geometric data

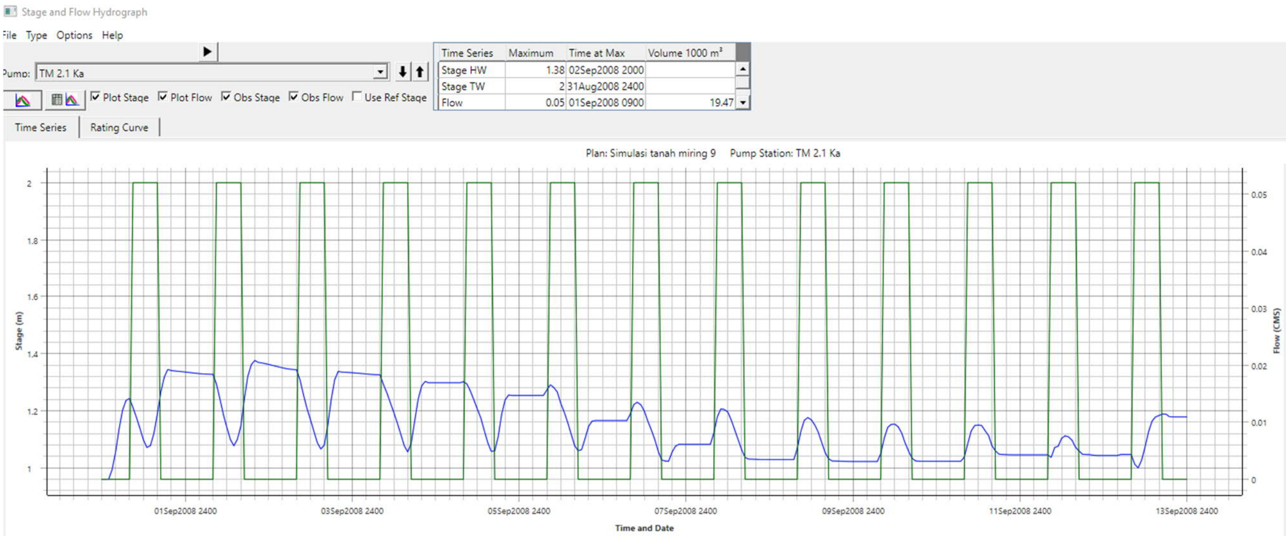
Figure 4-10 Tanah Miring SP 2,4, and 7 geometric data

Figure 4-11 Intake structure model in HEC-RAS



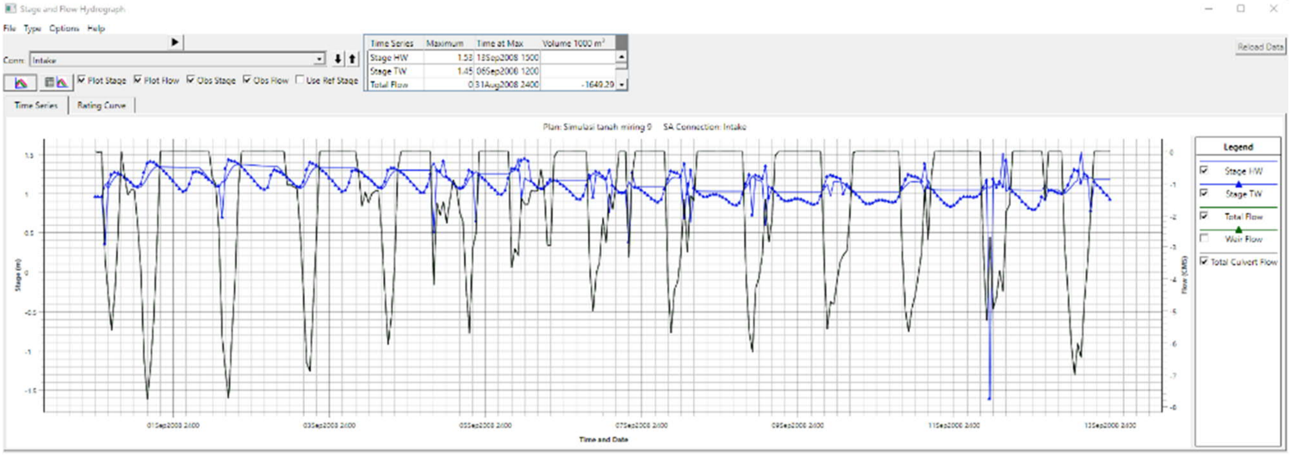
The HEC-RAS model is determined to be successful if the pump operation in each collector and secondary pump continues for 8 hours of operation in 1 day and there is also no error in the final summary result of the simulation. For irrigation supply an 'out of system' pump function in HEC RAS is used so that water is taken from the channel which is simulated as an intake structure to take water from the storage. The result of pump station operation is shown in Figure 4-12 below. the blue line is the water level in the channel. the water level in the channel will drop during pumping and will be filled again when the pump is off during the high tide cycle.

Figure 4-12 Pump station operation in Tanah Miring SP9



The intake structure model using flap gates produces sufficient discharge to meet the needs of irrigation augmentation for 8 hours. Incoming water does not continuously depend on the elevation of the water level in the river and also the water level in the channel. The result of intake structure flow on Tanah miring SP 9 can be shown in Figure 4-13.

Figure 4-13 Intake structure flow and stage hydrograph



4.7 Irrigation canal modelling

4.7.1 Intake structure

Generally, there are two types of intake structures designed on the scheme.

Type 1 is at the river bank taking water directly from the river and is equipped with a sill to exclude bed loads although most water entering the schemes will be during the dry season when there is little suspended sediment and most material in the river will be colloidal clays that generally will be transported through the canal system.

Type 2 is set back from the river often due to issues of land ownership but also because the structure is consistent with the flood bank. This intake depends more on the ability to draw water through the approach channel which can become blocked with debris, vegetative growth and sediment.

The intakes also operate in two different ways:

Those that are well upstream where water levels vary with river flows and can be designed on the basis of a static minimum upstream water level.

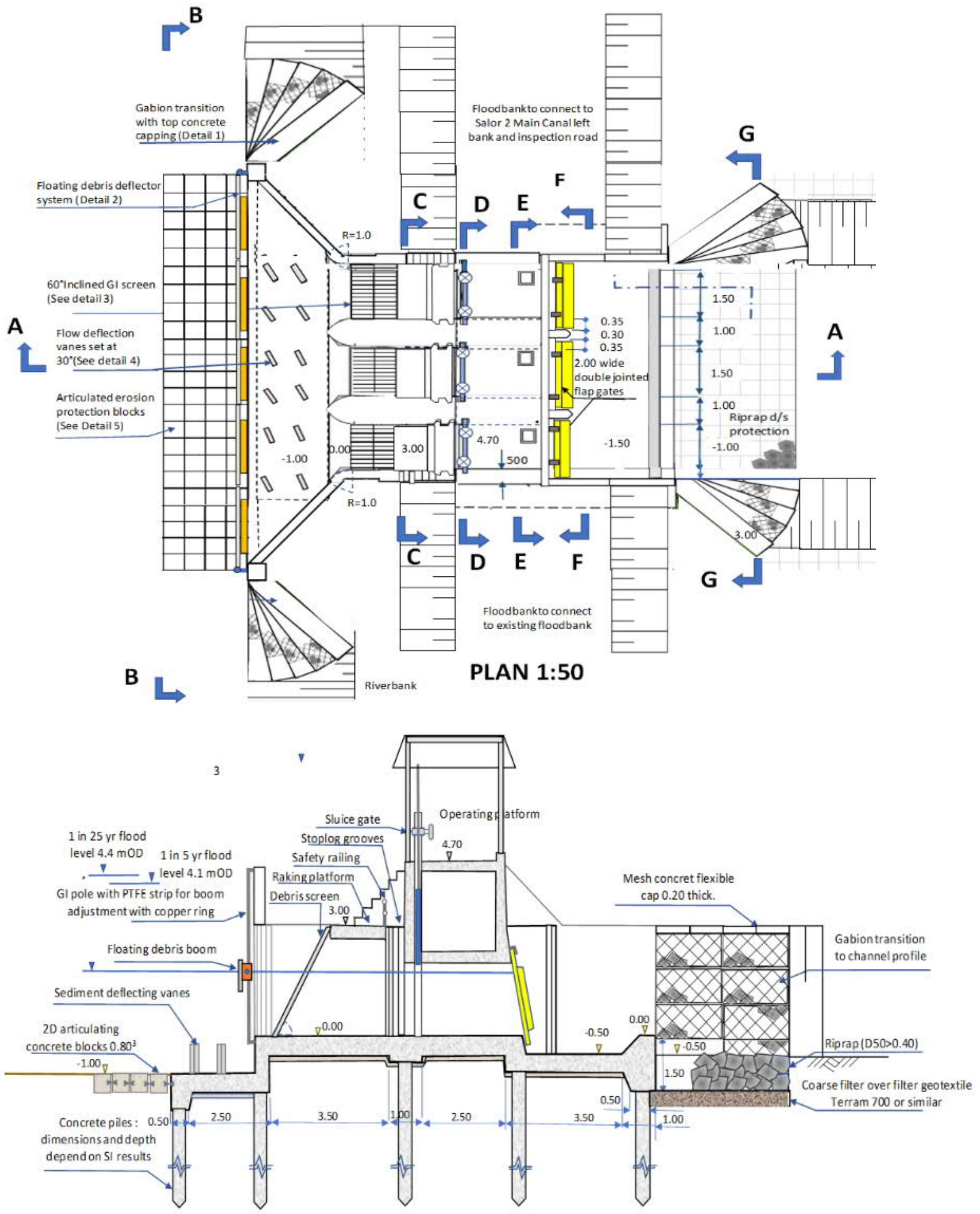
Those that are closer to the coast where tidal effects create a dynamic situation that can be used to partially fill the canals at high tide. These intakes are equipped with flap gates so that once the tide starts to ebb and river water levels drop below canal levels, the gates automatically close to retain water inside the scheme. These intakes can also be manually closed when salinity levels are greater than can be tolerated by the crops

The intake has the function of diverting water from the river in the needed quantities based on irrigation demands. The river intake structures under the Phase 1 program feature a protective apron with a sill to reduce sediment entry and debris deflection booms and raking screens to prevent floating debris from entering the canal system. Some of the intakes at the river bank also have flow deflecting vanes to maintain the deep pool in front of the intake and gabion transitions into the natural river bank slope to stabilise the soils and prevent bank erosion.

The intake should preferably be situated at the end of a large radius outer bend of the river where flows are deepest making facilitating drawing water into the intake or in a straight stretch to minimize the entrance of sediment.

It is important, especially around the intake, to design the wing walls and guide walls in such a way, that turbulence is avoided as much as possible, and the flow entry is smooth. This means that structure transitions are achieved by rounding walls with a minimum radius of the depth of half of the design depth of water at entry or 1m, whichever is largest. An angled approach of the flow rather than it having to turn 90°is preferred. An example showing the Salor 1,2 and 4 intake is shown on Figure ……

Figure 4-14 Example of intake structure



The intake structures are consistent with the alignment of flood banks. The intake sluice is equipped with sluice gates and flap gates. It has a closed front to guard against high water level during floods up to 1: 25 year return period with a 0.5 m freeboard to allow for climate change impacts and a 0.30 allowance during construction for settlement. Under flood conditions, when there might be suspended sediments the intake scour gates would normally be closed. The size of the gate opening depends on the maximum scheme demand and the allowable velocity through it. This velocity depends on the size of the grain of the material that can be transported.

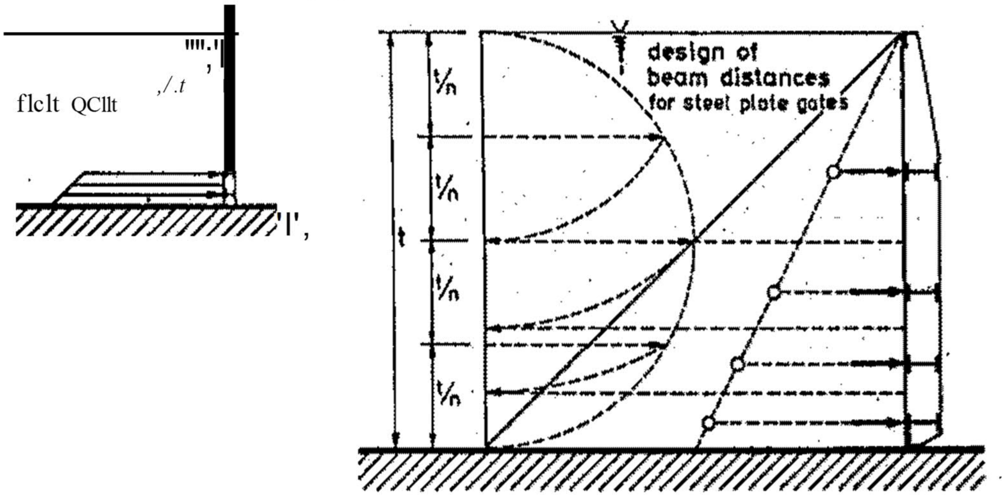
The capacity of intake should be at least 120% of the diversion requirement, in order to add flexibility and to be able to meet peak demands of the project.

4.7.2 Gates

Gate design should take into considerations, (i) the type of gate with sluice and flap gates the most commonly used, (ii) the load against the gate, (iii) the hoisting device can be manually or mechanically, (iv) the water tightness and seal, and (v) materials for construction.

The load of the gate: Water pressures against the gate are transferred to the grooves for sliding gates and to the central bearings for a radial gate. A wooden sliding gate is designed in such a way that each individual wooden beam is capable of bearing the load and transferring the load to the grooves; for steel sliding gates the forces have to be carried by beams. For glass fibre and HDPE gates the forces are distributed around the whole gate but transferred to the frame by the area in contact.

Figure 4-15 Forces on gates



Hoisting device: The hoisting device with a bronze curling nut which has a screw thread is normally used for the smaller gates as it prevents seizing with the thread on the spindle. For gates that will close due to their own dead weight chains or high-tension stainless-steel cables can be used instead of spindles.

The choice between human power or mechanical power depends on. the size and weight of the gate, the availability of electrical power. On the scheme designs a maximum width of 1.5m for manual operation using two spindles has been determined. Larger gates will be equipped with electric actuators that can also measure gate aperture and transmit it along with water level by sensors by telemetry to control offices. Further information on hydraulic gates can be found in the Hydromechanical Report.

The allowable operation time will depend on the gearing ratio and the allowable torque on the gate wheel for manually operated gates and on the power that can be applied by the electrical motor for electrically operated gates.

Flap gates: Flap gates operate automatically depending on the difference of head across them. If higher on the inner face they will open, and if greater on the outer face they will close. On the project they tend to be used in three situations:

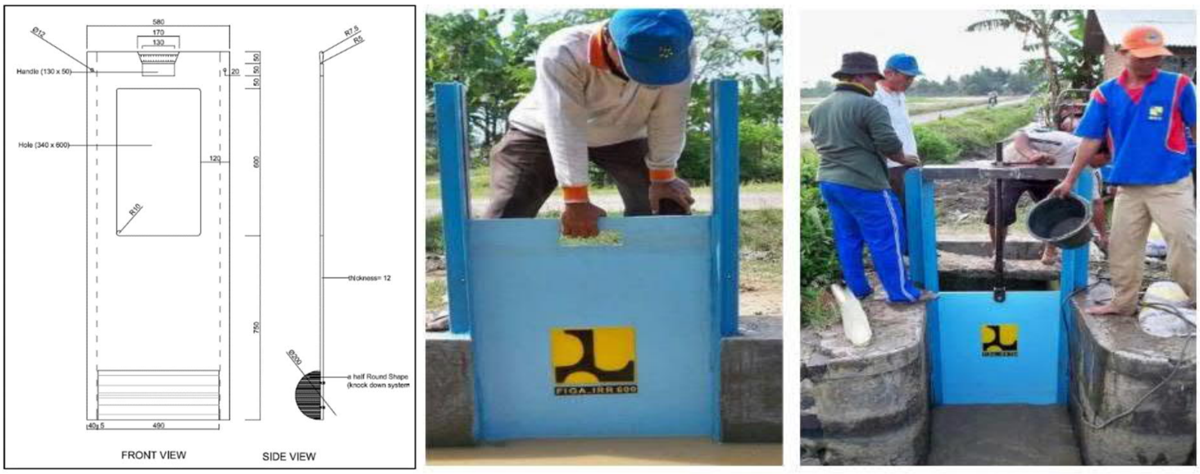
a. At the river intake that is influenced by tidal water movement, so that once the high tide has partially filled the canals, the gate closes as the tide ebbs to prevent loss of water from the canal back into the river.
b. At the pump station bypass so that pumped water does not drain back through the bypass.
c. At drainage outlet structures to allow internal drainage water out but not allow flood water from high river levels into the scheme.

Figure 4-16 HDPE flap gates (a) Rectangular for intake (b) circular for pump station bypass

Materials: Sluice and flap gates in the past have been made from steel or timber and often have had short lives due to poor maintenance causing rusting or rotting. Steel gates, particularly in near tidal lowlands where they may be subjected to acidic or saline water should have both gate leaf and frame hot dipped galvanised or painted with rust proof paint covered with a heavy duty and durable epoxy resin paint.

Newer irrigation Crump-de Gruyter gates have been made from glass-fibre and HDPE. As well as being resistant to acid and saline environments they also have to be UV light resistant.

Figure 4-17 Glass fibre offtake



4.7.3 Bridges

The types of bridges discussed here are vehicle bridges used on inspection roads, channel crossings, footbridges, and structure operational bridges.

Concrete bridges for roads that cross irrigation canals or drains that will be outside the authority of the irrigation service, should be planned and designed in accordance with the Bina Marga Standards. For this purpose, Bina Marga has established Bridge Planning Standards. The loading of the bridge is given in, Section KP-06 – Structure Parameters.

For bridges on Class I and II roads, planning and drawings, standard images already exist from Bina Marga and set out in KP-04. Bridges on class III, IV and V roads are constructed as:

- Concrete slab bridge if the span is less than 7 m although some additional support would be gained from integrating the kerbs into the design.
- For larger expanses there are integrated beams analysed as T-beams.
- The larger span bridges could also be constructed from precast, post tensioned concrete T or V beams.

The cost of concrete in Merauke is exceedingly high so that other materials can be used to make limited loading bridges such as on canal inspection roads or footbridges across canals. As many of these canals are over-wide they require bridges that span up to 24m. The usual span of concrete slab bridges is about 7m before it is more efficient to integrate T beams into the cross section. The efficient width of an integrated in-situ concrete T beam bridge is about 15m.

For road bridges an option is to ship precast prestressed concrete beams from factories in Java. The deck can be precast concrete slabs with an in-situ wearing coarse on top or in-situ concrete decks.

For footbridges an option would be to have steel footbridges manufactured in Java as components that are hot dipped galvanised for ease of transport. They would then be assembled by bolting together at site. The slabs are galvanised steel gratings commonly found on industrial complex walkways. The figure provides bolting details. The design for footbridges will provide a standard drawing with a series of spans for both types of bridges including steel and concrete beam properties to allow the bidding contractor to choose the design and provide alternative bids for this part of the works.

Wooden span bridges would seem an obvious choice as the area is surrounded by forest and some trees will have to be removed when improving the access roads. Brick arch bridges are another solution if good quality bricks could be made in Merauke. Yet here again is a pair of environmental issues: the damage to land in obtaining the brick clay and the use of timber or charcoal to fire the bricks. although this might have a limited life. These bridges could be considered during Phase 2 once further clarification on the quality and what permissible timber and bricks could be used are further investigated.

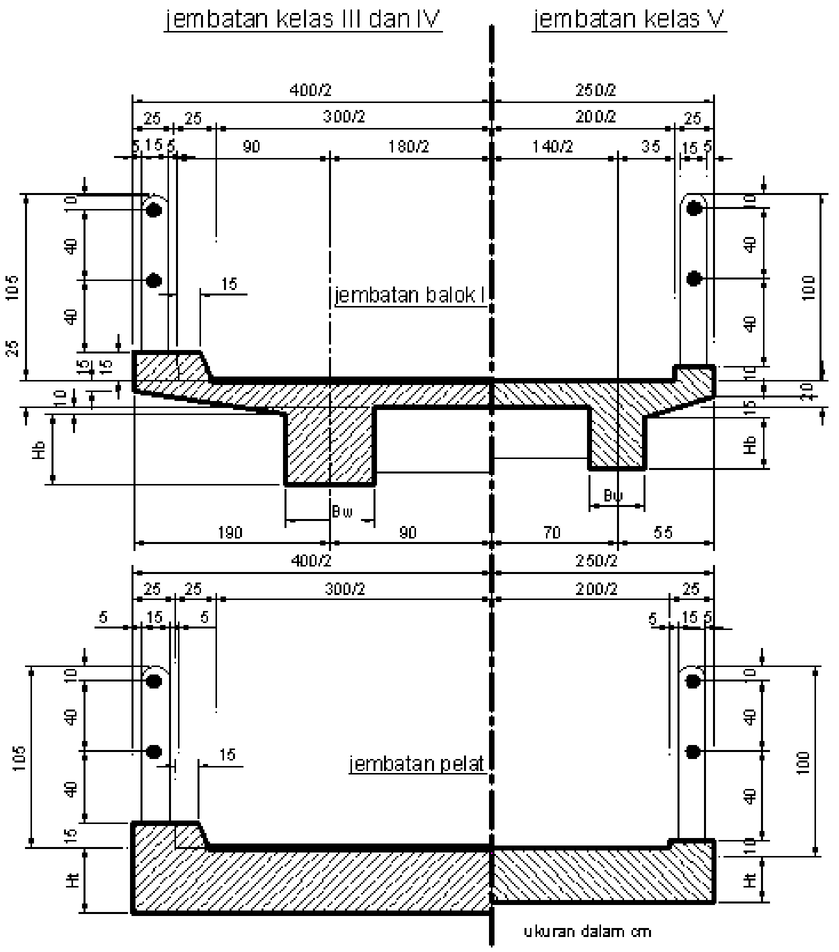
The soffit of the bridge should be located in elevation above or at the freeboard level of the canal to prevent interference with the flow. This may require a modest raising of the approach inspection road. The ends of the bridge span transfer the loading onto the bridge abutments and their foundations. Clearly the bearing capacity of the soil determines the plan area of the foundations if they are spread footings. If near surface soils have a high bearing capacity, the foundation can be in the form of spread footings where the surface area bearing capacity has a higher bearing capacity compared to the load on it to an accepted factor of safety. If the load is greater and the carrying capacity of the underground soil is not strong enough, piles can be used. Piles can be made of concrete, steel, or wood or a composite of steel and concrete.

Soil tests that have been obtained from the project area indicate that some of the soils are soft down to about 6m and generally too deep for spread footings or the mass masonry footings shown in the KP-04. There are several options for the designer:

a. For bridges that are large spans, one or more piers could be provided in the channel to support the upper structure to reduce the load on the abutment supports.
b. As piers in canals can trap floating debris, as above stated, large bridge spans can be achieved using prestressed precast beams in which abutment support can be achieved using piles. In this case a spread reinforced concrete footing is preferred so that the piles can be tied into the footing reinforcement.

An alternative to piles if sound souls can be found between 3 to 5m below ground level are caissons, either round or square, with cutting shoes so that the caisson is lowered by excavation within.

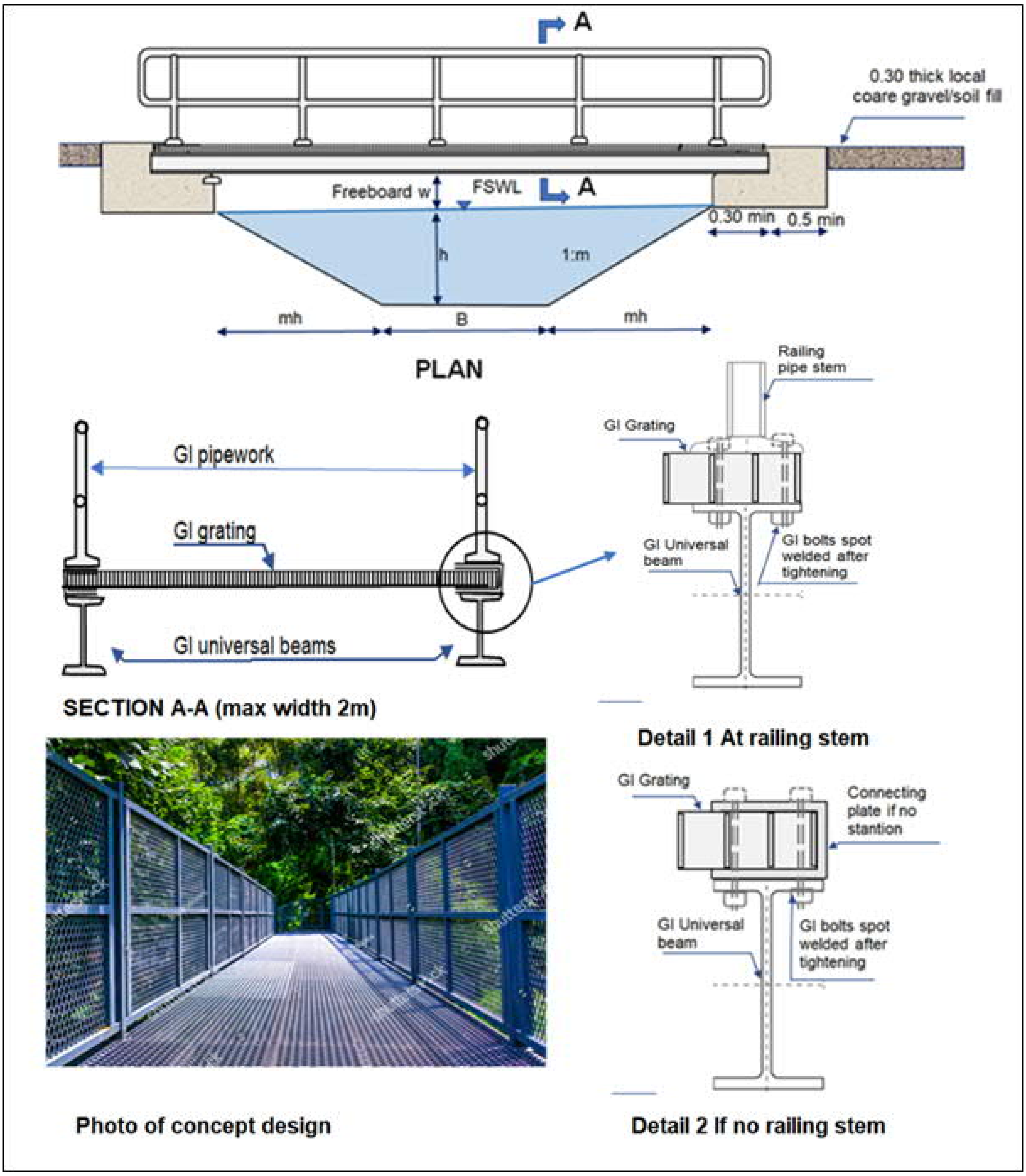
Figure 4-18 Type of bridge spans T-beam bridge and slab footbridge



From the figure above it appears that the base of the bridge should be below the line with a slope of 1 to 4 from the base of the channel. An additional requirement shown is to be below the line parallel to the side slope at a distance of 2.50 m from the base of the canal. For lined canals shown with a side slope of 1:1 the offset along the horizontal line from the base of the canal can be relaxed to 1.5m.

For lightweight footbridges made from galvanised steel or wood, the required depth of footing can be relayed by having a concrete plinth where the soil bearing capacity can be well in excess of the abutment loading.

Figure 4-19 Concept design of a galvanised steel footbridge



5 Flood protection

5.1. General

The Government aims to reduce the impacts of flooding on people, communities and infrastructure in the lowland irrigation development of Merauke. Integrated flood hazard management helps local governments, diking authorities, provincial ministries and others to (i) manage land use in the hazard area, (ii) manage flood protection system, and (iii) doing the mitigation programs.

Experience has shown that land use management and flood-proofing in areas susceptible to flooding is the most practical and cost-effective way to reduce the effects of flooding on lives and property. This approach requires the cooperation of all levels of government, and the public.

Well-designed structural measures can be highly effective in reducing flood damage when used appropriately; however, they can inherently reduce the risk of flood in one location while increasing it in another.

Dikes are only designed to defend against a predetermined level of flooding and they are subject to weaken or fail over time due to erosion, overtopping, seepage or seismic activity. It is not cost-effective to control the threat of all floods through the construction of dikes and other flood protection structures. However, at this moment dikes to avoid damage of water destruction in the area should be implemented before other measures will be carried out.

Emergency preparedness, response and recovery are essential for public safety, these activities may not prevent economic damage or entirely reduce the risk of loss of life and trauma.

As defined, a dike can be an embankment, wall, or fill piling, or any other thing that is constructed, assembled, or installed to prevent the flooding of land. But, for the lowland irrigation area, will be in the form of an embankment, that address major flood hazards.

In order to implement suitable protection measures, and to avoid making a problem worse or pushing the problem to another jurisdiction, several things should be clear: (i) Type of flood, (ii) Source of flooding, (iii) Probability of flooding, and (iv) Vulnerability of assets

Flooding is a common occurrence the area. Numerous conditions contribute to flooding, either acting alone or in combination with other flood conditions to result in more severe flood events. In lowland irrigation areas in Merauke, floods normally caused by climatic conditions: intense rainfall, and on few occasions by storm surges.

5.2. Flood discharge and modelling

Flood estimates are required for the design of weirs. The required design standard is expected to be a 100-year return period flood, incorporating allowance for climate change.

In the absence of flow records estimated flood magnitudes have been derived using a rainfall-runoff model. The simulated flows can then be used in a hydraulic model to study the extent of potential flooding, and the impact of any proposed flood protection measures.

Flood estimates made using a rainfall-runoff model are very often done using the estimated daily rainfall for a particular return period, based on the availability of data. For these catchments, however, a longer duration is required because the topography (particularly the very low slopes) means that it may take several days for all parts of the catchment to contribute to flow at the point of interest. Based on the estimated time of concentration a 5-day duration was chosen. The estimated rainfalls for a range of return periods are shown in The Hydrology Report. These are point rainfalls; in the flood assessment an area reduction factor (ARF) was applied to reflect the fact that average rainfall across the catchment will be lower than a design point value. The ARF is related to the catchment area, with a greater reduction for the Maro catchment than for the smaller Kumbe catchment.

Table 5-1 5-day rainfalls at Mopah for a range of return periods

Return period (years)	Rainfall (mm)
2	227
5	297
10	339
25	389
50	424
100	457

The flood discharges were estimated using the SCS method, taking account of catchment characteristics derived from mapping, with results as shown in **Table 5-2**. The hydrographs for the Maro are illustrated in the Hydrology Report, with the routing effect for the 100-year flood on the Kumbe illustrated in the Hydrology Report. There would be substantial attenuation of the flood peak, by more than 50%.

Table 5-2 Estimated peak flows for a range of return periods

Return period (years)	Kumbe flow (m^3/s)	Maro flow (m^3/s)
5	986	1434
10	1148	1708
25	1341	2034
50	1475	2263
100	1602	2481

The preliminary assessment of 1 in 5-year and 1 in 25-year return period floods in the Kumbe and Maro Rivers is described in the Hydrology Report and shows that if design floods are generated, they cause large areas to be inundated. The study has now been repeated using the LiDAR DEM, which indicated flooding is even more widespread than first modelled. The simulation of the HEC-RAS flood model in the feasibility area shows that with no flood protection, the large extent of flooding in both 1 in 5 years (in **Figure 5-1**) and 1 in 25 years (**Figure 5-2**) situation. The former is the usual protection given to agricultural land whilst the 1 in 25-year situation is normally given to rural communities and has an allowance of 0.75 m on the tidal boundary condition for SLR and a component for storm surge.

In the feasibility study it is assumed that this would represent the Scenario 1 reactive approach where a limited budget would just about maintain this risk in a worsening climate. The areas of inundation in terms of loss of productive rice land are averaged over a year would affect without project benefits equally every year.

For Scenario 2, strategy 1 the cost of flood protection will be built into the costing model with each scheme protected in line with the phase it will be upgraded. The flood embankment is designed with a top level equal to the 1 in 25-year flood giving the 1 in 5 year flood a freeboard of about 200 mm and a settlement allowance of 300 mm. It appears that some 71 km of flood bank is necessary to protect these areas from 1:25 year flooding.

For Scenario 2, strategy 2, it is apparent that a dam built across the Kumbe would have a high capacity for flood storage. This is particularly effective if the upstream water levels can be operated at below weir levels during most of the wet season when irrigation flows are either well below design levels or not required then brought up to crest level towards the end. The models were operated in the model with the wet season water level at 9 mOD. This allows most of the 1 in 5-year flood to be accommodated within the reservoir drastically reducing flooding. Some minor flood works will also be necessary to close up gaps in the embankment often made for irrigation intakes or drain outlets that will be closed by structures by the Project. The reduced flooding is shown in the Master Plan Strategies Report for the 1 in 5 year and 1 in 25 year floods In the Kumbe Dam PFS economic analysis the with-project situation benefits from no flooding, except for some minor bank closures giving a large reduction in overall flood protection costs.

The conditions of each model operation, area inundated, and flood depth is given in and show the effectiveness of the Kumbe dam in reducing flooding.

Table 5-3 Details of flood modelling operations

No.	Return Period	Condition	Flooded area (ha)	Average depth (m)
1	5-year	Existing on Kumbe & lower Maro rivers, max tide 2 mOD	30,786	0.45
2	25-year	Existing on Kumbe & lower Maro rivers, max tide 2 mOD	39,383	0.55
3	25-year	Existing on Kumbe & lower Maro rivers, max tide 2.75 mOD	50,566	0.60
4	5-year	Kumbe River with barrage, max tide 2 mOD	8,241	0.43
5	25-year	Kumbe River with barrage, max tide 2 mOD	14,456	0.50
6	25-year	Kumbe with minor dikes, max tide 2 mOD	0	0
7	25-year	Kumbe with barrage and high tide of 2.75 mOD	23,450	0.43

Figure 5-1 HEC RAS flood model for 1 in 5-year flood without the Kumbe dam

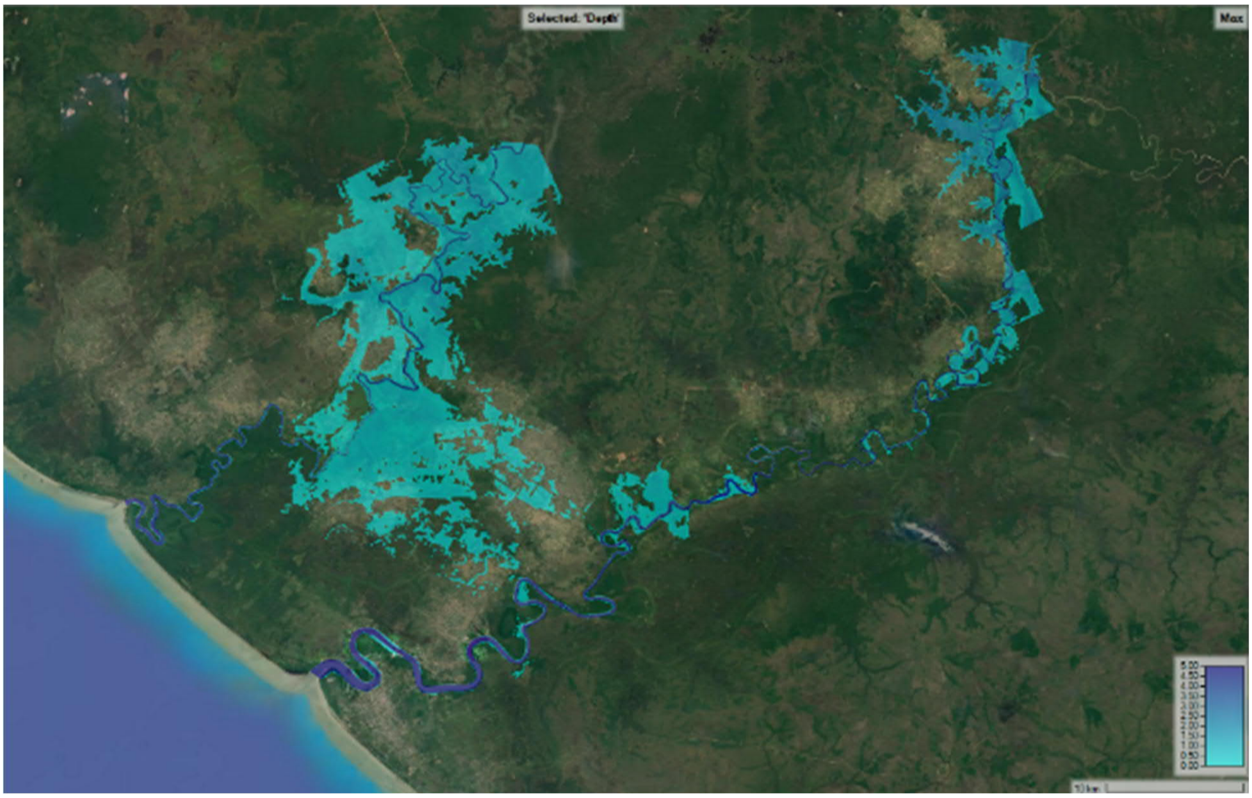
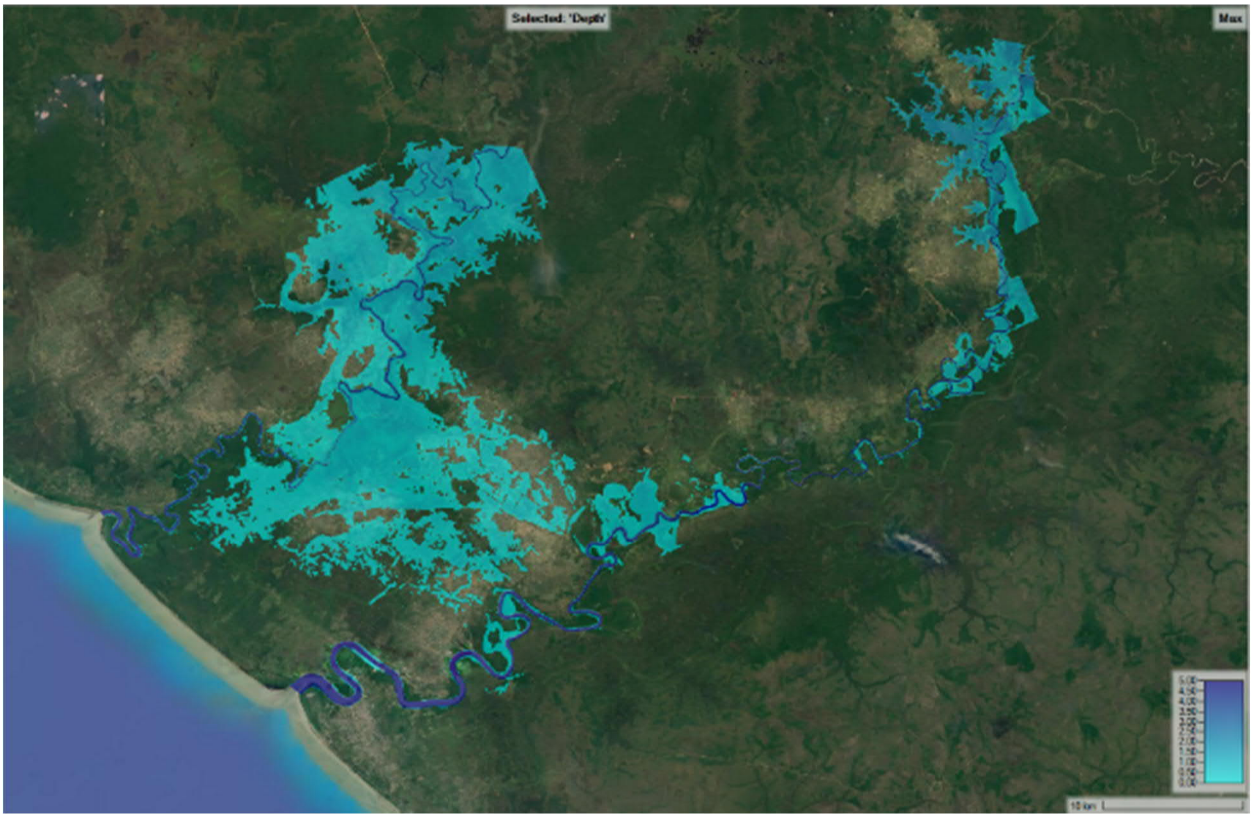


Figure 5-2 HEC RAS flood model without Kumbe dam for 1 in 25-year flood



Flood modelling for barrage design shows that 1 in 100-year floods can be retained within the Dam at elevation 11 mOD and the 1 in 1,000-year flood within an elevation of 11.5 mOD by mobilising an emergency spillway on the left bank. Further flood studies combined with social studies of local bankside communities are necessary during the FS during the Action Plan in Phase 1 to verify whether their areas above the dam would be inundated or that they are inconvenienced. This should be done during the proposed FS with a LiDAR DEM.

In future assessments, floods from the rivers have to be coordinated with flows emerging from the swamps and an updated assessment of storm surge risks. In Strategy 3, the control of Keramati swamp outlet flows will also reduce internal flooding.

There are 21 Villages affected by flooding with the return period of 25 Year, with the depth of 0.3 to 0.5 m, with the total of 229 Ha.

Table 5-4 Villages affected by flooding in the project area

No.	Villages	District	Flooded Area (ha)
1	Amun Kay	Tanah Miring	2.25
2	Harapan Makmur	Kurik	0.05
3	Hidup Baru	Tanah Miring	3.40
4	Isano Mbias	Tanah Miring	36.09
5	Kumbe	Malind	0.32
6	Kuper	Semangga	0.05
7	Marga Mulya	Semangga	10.29
8	Muram Sari	Semangga	3.24
9	Salor Indah	Kurik	0.05
10	Semangga Jaya	Semangga	3.88

No.	Villages	District	Flooded Area (ha)
11	Sido Mulyo	Semangga	0.07
12	Sumber Harapan	Tanah Miring	6.41
13	Sumber Rejeki	Kurik	0.99
14	Tambat	Tanah Miring	1.21
15	Telaga Sari	Kurik	45.99
16	Waninggap Kai	Semangga	21.75
17	Waninggap Miraf	Tanah Miring	33.57
18	Waninggap Say	Tanah Miring	26.29
19	Wonorejo	Kurik	3.83
20	Yaba Maru	Tanah Miring	26.68
21	Yasa Mulya	Tanah Miring	2.51
	Total Flooded Area		229

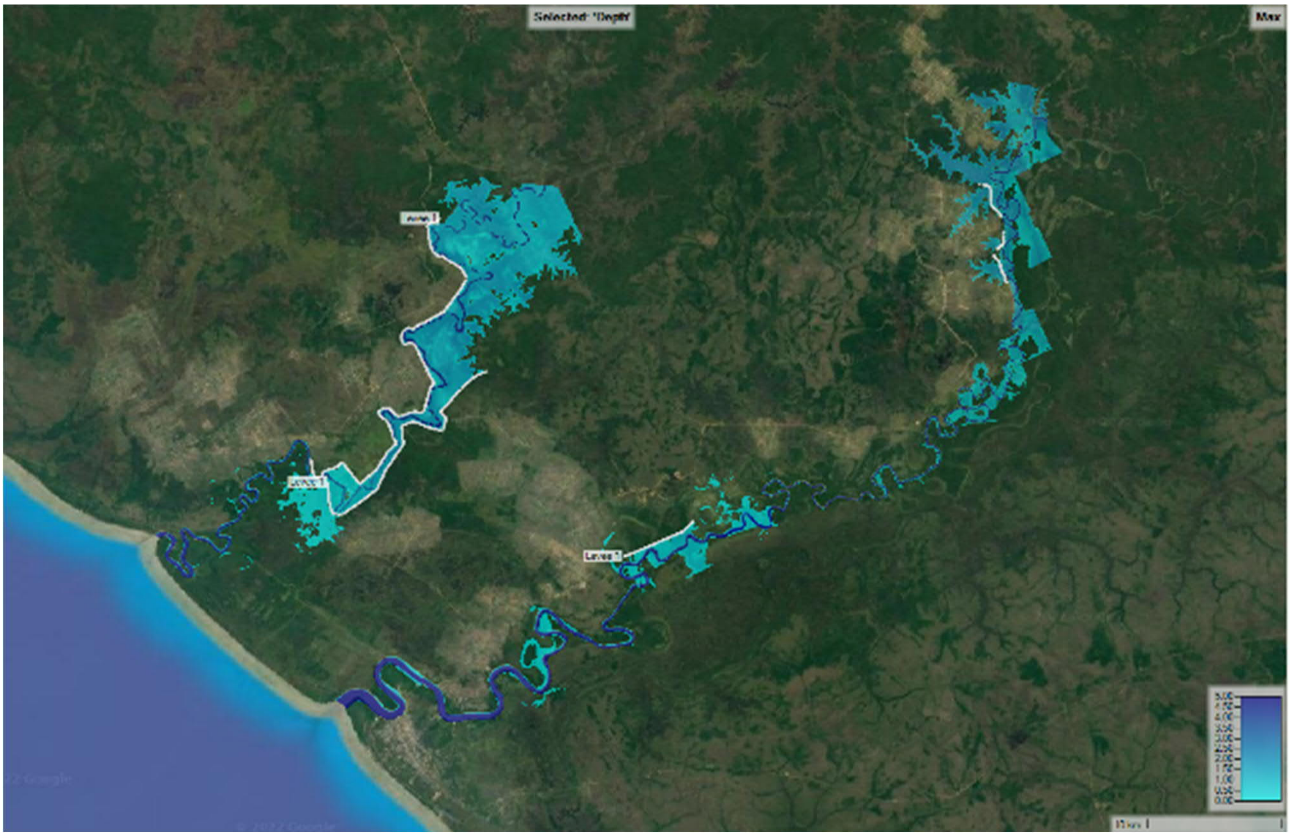
Table 5-5 Average flood depth per village

No.	Villages	District	Average depth (m)
1	Semangga Jaya	Semangga	0.23
2	Marga Mulya	Semangga	0.25
3	Muram Sari	Semangga	0.27
4	Waninggap Kai	Semangga	0.24
5	Amun Kay	Tanah Miring	0.18
6	Yaba Maru	Tanah Miring	0.22
7	Tambat	Tanah Miring	0.15
8	Wonorejo	Kurik	0.29
9	Sumber Rejeki	Kurik	0.51
10	Salor Indah	Kurik	0.26
11	Sido Mulyo	Semangga	0.64
12	Kuper	Semangga	0.24
13	Yasa Mulya	Tanah Miring	0.26
14	Sumber Harapan	Tanah Miring	0.25
15	Waninggap Say	Tanah Miring	0.23
16	Hidup Baru	Tanah Miring	0.22
17	Waninggap Miraf	Tanah Miring	0.26
18	Isano Mbias	Tanah Miring	0.22
19	Harapan Makmur	Kurik	0.25
20	Telaga Sari	Kurik	0.35
21	Kumbe	Malind	0.80

When a protection dikes installed to protect the flooding along those two rivers, the result can be seen in Figure 5-3 The dike with crest level of about +4.50 m to +5.0 m along the lower areas (The Scheme of Kurik, Salor, Semangga, Tanah Miring), and in the upper areas at +6.50m to +7.0 m (Jagebob Scheme).

It can be said that the average height of the dike is 2 m. With the crest width of 5 m, and the total length of 71 km

Figure 5-3 Inundated area along Kumbe and Maro River with Q25 with the dikes installed.



5.3. Flood protection infrastructure

The government responsibilities and general supervision relative to the construction and maintenance of dikes lies with the offices of the BWS's Inspectors of Dikes are as follows:

Their responsibilities include:

- Administering the *dike maintenance*
- Setting dike maintenance standards and other criteria
- Promoting dike management best practices
- Monitoring and auditing management of works by local diking authorities
- Approving changes to dikes and new dikes
- Providing technical expertise for high-risk diking issues

All dikes made of earth fill, compacted, layer by layer of 0.25 m, and compacted using tandem roller compactors 6-8 tons. The slope surface is turfed with grass except for those near river bends more susceptible to erosion are transplanted with vetiver grasses that have very deep and strong roots.

Dike design

The dimension of dike can be presented as follows:

Table 5-6 Dikes dimension

No.	Scheme	High Water Level	Top Elevation	Length (m)	Length (km)	Crest (m)	Notes
1	Tanah Miring SP 9	3.85	4.85	6,539.96	6.54	5	
2	Tanah Miring SP 6	3.60	4.60	7,024.69	7.02	5	
3	Semangga 3 & 4	3.10	4.10	7,410.69	7.41	5	
4	Kurik Salor 1	4.00	5.00	12,346.50	12.35	5	
5	Kurik Salor 2	3.85	4.85	12,346.50	12.35	5	

No.	Scheme	High Water Level	Top Elevation	Length (m)	Length (km)	Crest (m)	Notes
6	Kurik Salor 3	3.50	4.50	12,346.50	12.35	5	
7	Jagebob 1	6.10	7.10	3,456.54	3.46	5	
8	Jagebob 2	5.60	6.60	1,630.18	1.63	5	
9	Jagebob 3	5.45	6.45	2,518.71	2.52	5	

6 Technical specifications

Table 6-1 Technical specification

No.	Scheme /Structure	Major component	Technical Specification	Description/ categories
1	Canal	Earth works	Surface stripping of 0.30 m; stripping results are removed from the project area	
			Excavation using HER, w/ normal boom length; Excavated results are used for embankment needs.	Hand excavation Machine excavation Excavation in soft ground.
			Land fill: uses local good soils. Layer by layer of 0.25m, compacted using sheet foot roller.	Earth fill (>5,000 m) Earth fill (500-5,000 m) Earth fill (50-500 m) Cut and fill Backfill
			Side slope: side slope is formed according to the design. The surface should be fitted with grass layer.	Grassing Flood bank protection with vetiver grass
			Inspection road (see item 4)	
2	Free intake structure, pump station civil works & drainage outlet	Foundation	Use wooden pile foundation, 0.5m space between pile. Dia 10-15 cm; It should reach the strong soil layer (around 3 m deep). Precast concrete piles for large structures and deeper firm ground.	Depends on site investigation using DCPs,
		Concrete	Using K225 concrete, over the lean concrete. Reinforcement: uses plain bar; Finishing: plaster of 1 PC: 3 Ps, 1.5m cm thick;	Blinding concrete/work floor
		Slide gate	Use non-corrosive materials and painted; motorized for gate of more than 1.5 m wide. Equal or less 1.5 m wide, manually operated. All open side must be painted using good epoxy metal paint.	HDPE and fibreglass may be considered, Contractor to provide shop drawings and factory inspections.
		Flap gate	Use non-corrosive materials with good bearing for the hinge. The gate should be water tight, using rubber sealer. All open side metal gates must be painted using good metal paint. Consider HDPE or fibreglass gates.	Installed to manufacturer's instructions.
		Stop logs	Wooden stop logs with the thickness of 0.15 m; and stand on the structure wall groove of 10 cm notch.	
		Abutments	Gabion transitions to limit structure needing piling, with mesh concrete articulating slabs top surface.	On softer soils gabions tolerate greater settlements.
3	Division structure	Foundation	Use wooden pile foundation, 0.5m space between pile. Dia 10-15 cm; It should reach the strong soil layer (around 3 m deep). On firm soils can use spread footings and masonry structures.	On structures transitioning into wide canals use gabion transitions,
		Concrete	Using K225 concrete, over the lean concrete. Reinforcement: uses plain bar; Finishing: plaster of 1 PC: 3 Ps, 1.5m cm thick;	

No.	Scheme /Structure	Major component	Technical Specification	Description/ categories
		Masonry	On firm soils use 1:3 mortar on water contact faces and 1:4 on all other.	
		Slide gate	Use non-corrosive materials and painted; motorized for gate of more than 1 m wide. Less 1 m wide, manually operated.	
		Stop logs	Wooden stop logs with the thickness of 15 m; and stand on the structure wall groove of 10 cm notch.	
		Measurement structure	Made of concrete, equipped with 2 staff gauges, one on the upstream, and one on the downstream.	Broad crested weir. Ensure nappe aerated.
		Pumps	See the specification in M&E Report.	
4	Inspection road	Foundation	Coarse soils with gravels compacted	
		Pavement	Uses sand and soil mixture, compacted	
5	Culvert	Foundation	For concrete pipe or rectangular box use wooden pile foundation if soft ground, 0.5m space between pile. Dia 10-15 cm; It should reach the strong soil layer (around 3 m deep) For Armco or HDPE culverts, based on granular soil bed D/4 thick.	Culverts in excessively large canals or as pump bypasses.
		Concrete	Using K225 concrete, over the lean concrete. Without reinforcement. Finishing: plaster of 1 PC: 3 Ps, 1.5m cm thick;	
			Armco culvert pipes > 1m dia shipped dismantles and nested. HDPE for pump bypasses with outlet fitted flap gates. Use 2 different sizes that can be nested.	
6	Foot bridge	Foundation	Use wooden pile foundation, 0.5m space between pile. Dia 10-15 cm; It should reach the strong soil layer (+/- 3 m deep) On firm soils use spread concrete footing.	
		Concrete abutment	Using K225 concrete, over the lean concrete. Reinforcement: uses plain bar; Finishing: plaster of 1 PC: 3 Ps, 1.5m cm thick;	
		Girder	Uses 2 No. I beams;	
		Deck	Uses wooden floor, 10 cm thick: GI grating or chequer plate.	Width <2m to exclude heavy vehicles
7	Road bridge	Foundation	Use wooden pile foundation, 0.5m space between pile. Dia 10-15 cm; If strong soil layer to 3 m depth. For deeper firm soils use precast R/C concrete square piles.	Follow Bina Marga Regulation
		Concrete abutment	Using K225 concrete, over the lean concrete. Reinforcement: uses plain bar; Finishing: plaster of 1 PC: 3 Ps, 1.5m cm thick;	
		Girder	Reinforced concrete, K225	
		Concrete Floor	Reinforced concrete, K225	

7 Engineering cost estimate

7.1 Summary of cost estimate

Summary of Engineering Cost Estimate

WORKS : MERAUKE IRRIGATION SCHEME
FISCAL YEAR : 2022-2026
PROJECT LOCATION : MERAUKE REGENCY, PAPUA PROVINCE

NO.	WORKS ITEM	AMOUNT (Rp)
1	PACKAGE-1	557,726,900,000
	KURIK 1, KURIK 2 & SALOR KAMPUNG, KURIK 5 & 6	
2	PACKAGE-2	400,461,100,000
	SALOR 1,2,3,4, TANAH MIRING 9	
3	PACKAGE-3	448,094,900,000
	LOWER JAGEBOB, SERMAYAM	
4	PACKAGE-4	262,991,200,000
	TANAH MIRING 2,4,7, SIDOMULYO, SALOR KAMPUNG, KUMBE KAMPUNG	
	TOTAL	1,669,274,100,000
	VALUE ADDED TAX (10%)	
	GRAND TOTAL	1,669,274,100,000
	ROUNDED	1,669,274,100,000

7.2 Engineering cost estimate of Package 1

ENGINEER'S COST ESTIMATES (EE)
HARGA PERKIRAAN PERENCANA (HPP)

WORKS	:	Reconstruction of Merauke Main Canal, Secondary Canals and Drainage Canals
PEKERJAAN	:	Rekonstruksi Saluran Primer Merauke, Saluran Sekunder, dan Saluran Pembuang
FISCAL YEAR	:	2022-2026
TAHUN ANGGARAN	:	2022-2026
PROJECT LOCATION	:	Kurik 1, Kurik 2, Kurik 5 & 6, Merauke Regency, Papua Province
LOKASI PROYEK	:	Kurik 1, Kurik 2, Kurik 5 & 6, Kabupaten Merauke, Provinsi Papua

NO	WORKS ITEM URAIAN PEKERJAAN	Unit Satuan	Quantity Volume	Unit Price (Rp) Harga Satuan (Rp)	Amount (Rp) Jmlah Harga (Rp)	Weight (%) Bobot (%)
1	**PEKERJAAN PERSIAPAN**					
1.8	Mobilisasi dan Demobilisasi	LS	1.00	350,520,000	350,520,000	0.06
1.9	Laporan dan Foto	LS	1.00	250,573,500	250,573,500	0.04
1.10	Direksi keet / Contractor's site office	LS	1.00	888,300,000	888,300,000	0.16
1.11	Keselamatan dan Kesehatan Kerja	LS/month	56.00	11,195,000	626,920,000	0.11
1.12	Covid-19 screening test, mitigation protocol and medical check-up	LS/month	56.00	45,602,500	2,553,740,000	0.45
1.13	Provision and maintence of project signs / Papan Nama Proyek	Set	4.00	1,030,400	4,121,600	0.00
				Sub Total - 1	**4,674,175,100**	**0.83**
2	**PEKERJAAN SALURAN PRIMER (L = 41.97 km)**					
2.1	Galian Tanah Biasa Tenaga Alat	m^3	2,248,523.52	55,800	125,467,612,383	22.32
2.2	Timbunan Tanah Setempat dipadatkan	m^3	5,335.29	103,200	550,602,031	0.10
2.3	Kupasan / Stripping of top soil	m²	5,886.52	10,700	62,985,716	0.01
2.4	Gebalan Rumput	m²	215,680.77	21,100	4,550,864,171	0.81
2.5	Backfill	m^3	-	59,200	-	-
2.6	Sub Base Course (Jalan Inspeksi)	m²	75,540.96	160,200	12,101,661,792	2.15
2.7	Base Course	m²	50,360.64	106,800	5,378,516,352	0.96
				Sub Total - 2	**148,112,242,445**	**26.35**
3	**PEKERJAAN SALURAN SEKUNDER (L = 84.65 km)**					
3.1	Galian Tanah Biasa Tenaga Alat	m^3	213,155.75	55,800	11,894,091,017	2.12
3.2	Timbunan Tanah Setempat dipadatkan	m^3	800,363.76	103,200	82,597,539,733	14.70
3.3	Kupasan / Stripping of top soil	m²	762,789.18	10,700	8,161,844,270	1.45
3.4	Gebalan Rumput	m²	405,506.08	21,100	8,556,178,362	1.52
3.5	Backfill	m^3	-	59,200	-	-
3.6	Sub Base Course (Jalan Inspeksi)	m^3	91,425.15	160,200	14,646,309,607	2.61
3.7	Base Course	m^3	60,950.10	106,800	6,509,470,936	1.16
				Sub Total - 3	**132,365,433,925**	**23.55**
4	**PEKERJAAN SALURAN DRAIN PRIMER (L = 2.26 km)**					
4.1	Galian Tanah Biasa Tenaga Alat	m^3	93,892.39	55,800	5,239,195,457	0.93
4.2	Timbunan Tanah Setempat dipadatkan	m^3	-	103,200	-	-
4.3	Kupasan / Stripping of top soil	m²	-	10,700	-	-
4.4	Gebalan Rumput	m²	13,486.38	21,100	284,562,555	0.05
4.5	Backfill	m^3	-	59,200	-	-
4.6	Sub Base Course (Jalan Inspeksi)	m^3	2,439.72	160,200	390,843,144	0.07
4.7	Base Course	m^3	1,626.48	106,800	173,708,064	0.03
				Sub Total - 4	**6,088,309,220**	**1.08**
5	**PEKERJAAN SALURAN DRAIN SEKUNDER (L = 85.09 km)**					
5.1	Galian Tanah Biasa Tenaga Alat	m^3	2,339,535.49	55,800	130,546,080,392	23.23
5.2	Timbunan Tanah Setempat dipadatkan	m^3	70,403.49	103,200	7,265,640,003	1.29
5.3	Kupasan / Stripping of top soil	m²	126,960.87	10,700	1,358,481,357	0.24
5.4	Gebalan Rumput	m²	532,030.02	21,100	11,225,833,342	2.00
5.5	Backfill	m^3	-	59,200	-	-
5.6	Sub Base Course (Jalan Inspeksi)	m^3	91,892.88	160,200	14,721,239,376	2.62
5.7	Base Course	m^3	61,261.92	106,800	6,542,773,056	1.16
				Sub Total - 5	**171,660,047,526**	**30.54**
6	**PEKERJAAN TEMPORARY COFFERDAM & DEWATERING**					
6.1	Temporary Cofferdam	LS	1.00	37,931,000	37,931,000	0.01
6.2	Dewatering (by pumping system) at all site	LS	-	-	-	-
				Sub Total - 6	**37,931,000**	**0.01**
7	**PEKERJAAN BANGUNAN INTAKE**					
7.1	Beton K-225	m^3	67,411.18	1,339,100	90,270,314,838	16.06
				Sub Total - 7	**90,270,314,837.77**	**16.06**
8	**PEKERJAAN STRUKTUR BANGUNAN**					
8.1	Talang	unit	10.00	28,750,150	287,501,500	0.05
8.2	Sipon	unit	5.00	75,515,325	377,576,625	0.07
8.3	Jembatan	unit	4.00	135,750,115	543,000,460	0.10
8.4	Jembatan Orang	unit	2.00	165,550,125	331,100,250	0.06
8.5	Gorong-gorong	unit	20.00	35,875,115	717,502,300	0.13
8.6	Pipa	unit	3.00	25,150,330	75,450,990	0.01
				Sub Total - 8	**2,332,132,125.00**	**0.41**

NO	WORKS ITEM URAIAN PEKERJAAN		Unit Satuan	Quantity Volume	Unit Price (Rp) Harga Satuan (Rp)	Amount (Rp) Jmlah Harga (Rp)	Weight (%) Bobot (%)
9	**PEKERJAAN PUMP STATION MECHANICAL & ELECTRICAL WORKS**						
9.1	Fix Wheel Gate	a) b = 2,50 m ; h= 3,00 m	unit	1.00	441,340,000	441,340,000	0.08
		b) b = 2,50 m ; h= 2,50 m	unit	1.00	433,930,000	433,930,000	0.08
		c) b = 2,50 m ; h= 2,00 m	unit	1.00	426,390,000	426,390,000	0.08
9.2	Maintenance Stoplog	a) b = 1,50 m ; h= 1,50 m	unit	1.00	62,160,000	62,160,000	0.01
		b) b = 2,00 m ; h= 1,50 m	unit	1.00	72,560,000	72,560,000	0.01
		c) b = 2,50 m ; h= 1,50 m	unit	1.00	75,810,000	75,810,000	0.01
9.3	Timber Stoplog	a) b = 1,50 m ; h= 2,00 m	unit	1.00	42,010,000	42,010,000	0.01
		b) b = 2,50 m ; h= 2,00 m	unit	1.00	49,550,000	49,550,000	0.01
		c) b = 2,50 m ; h= 1,60 m	unit	1.00	43,700,000	43,700,000	0.01
9.4	Slide Gate - Manual	a) 1A (KP-Standard)	unit	1.00	56,890,000	56,890,000	0.01
		b) 1B (KP-Standard)	unit	1.00	62,480,000	62,480,000	0.01
		c) 2A (KP-Standard)	unit	1.00	57,930,000	57,930,000	0.01
		d) 2B (KP-Standard)	unit	1.00	63,520,000	63,520,000	0.01
		e) 2C (KP-Standard)	unit	1.00	59,750,000	59,750,000	0.01
		f) 3A (KP-Standard)	unit	1.00	65,730,000	65,730,000	0.01
		g) 3B (KP-Standard)	unit	1.00	73,530,000	73,530,000	0.01
		h) 3C (KP-Standard)	unit	1.00	79,900,000	79,900,000	0.01
		i) 4A (KP-Standard)	unit	1.00	67,940,000	67,940,000	0.01
		j) 4B (KP-Standard)	unit	1.00	75,740,000	75,740,000	0.01
		k) 5A (KP-Standard)	unit	1.00	87,850,000	87,850,000	0.02
		l) 6A (KP-Standard)	unit	1.00	93,050,000	93,050,000	0.02
		m) 7A (KP-Standard)	unit	1.00	100,980,000	100,980,000	0.02
9.5	Flat Gate		unit	1.00	117,880,000	117,880,000	0.02
9.6	Handpull Gate		unit	1.00	21,340,000	21,340,000	0.00
9.7	Trashrack	a) b = 2,50 m ; h= 3,00 m	unit	1.00	86,040,000	86,040,000	0.02
		b) b = 2,50 m ; h= 2,50 m	unit	1.00	77,850,000	77,850,000	0.01
		c) b = 2,50 m ; h= 2,00 m	unit	1.00	69,660,000	69,660,000	0.01
9.8	Monorail Crane (Electric) 3T		unit	1.00	213,050,000	213,050,000	0.04
9.9	Monorail Crane (Manual) 3T		unit	1.00	72,780,000	72,780,000	0.01
9.10	Portal Crane (Manual) 3T		unit	1.00	130,240,000	130,240,000	0.02
9.11	Overhead Crane (Electric) 10T		unit	1.00	835,130,000	835,130,000	0.15
9.12	Monorail Crane (Electric) 5T		unit	1.00	252,960,000	252,960,000	0.05
9.13	Monorail Crane (Manual) 5T		unit	1.00	82,270,000	82,270,000	0.01
9.14	Lifting beam		unit	1.00	51,510,000	51,510,000	0.01
9.15	Trailer Pump 200 ls		unit	1.00	339,900,000	339,900,000	0.06
9.16	Trailer Pump 100 ls		unit	1.00	312,470,000	312,470,000	0.06
9.17	Trailer Pump 50 ls		unit	1.00	295,830,000	295,830,000	0.05
9.18	Trailer Pump 20 ls		unit	1.00	278,930,000	278,930,000	0.05
9.19	Fuel Storage Tank 50KL		unit	1.00	182,990,000	182,990,000	0.03
9.20	Fuel Storage Tank 25KL		unit	1.00	155,430,000	155,430,000	0.03
9.21	Fuel Storage Tank 10KL		unit	1.00	141,780,000	141,780,000	0.03
9.22	Fuel Storage Tank 5KL		unit	1.00	93,810,000	93,810,000	0.02
9.23	Fuel Storage Tank 1KL		unit	1.00	61,180,000	61,180,000	0.01
					Sub Total - 9	**6,465,770,000**	**1.15**
	TOTAL (1+2+3+4+5+6+7+8+9)					**562,006,356,178**	**100.00**
	VALUE ADDED TAX (10%) / PAJAK PERTAMBAHAN NILAI (10%) TIDAK DIPUNGUT						
	TOTAL / JUMLAH					**562,006,356,178**	
	ROUNDED / DIBULATKAN					**562,006,300,000**	
	SAYS: .... / TERBILANG:						

7.3 Engineering cost estimate of Package 2

ENGINEER'S COST ESTIMATES (EE)
HARGA PERKIRAAN PERENCANA (HPP)

WORKS	:	**Reconstruction of Merauke Main Canal, Secondary Canals and Drainage Canals (PACKAGE 2)**
PEKERJAAN	:	**Rekonstruksi Saluran Primer Merauke, Saluran Sekunder, dan Saluran Pembuang (PAKET 2)**
FISCAL YEAR	:	**2022-2026**
TAHUN ANGGARAN	:	**2022-2026**
PROJECT LOCATION	:	**Salor 1,2,3,4, Tanah Miring 9, Merauke Regency, Papua Province**
LOKASI PROYEK	:	**Salor 1,2,3,4, Tanah Miring 9, Kabupaten Merauke, Provinsi Papua**

NO	WORKS ITEM URAIAN PEKERJAAN	Unit Satuan	Quantity Volume	Unit Price (Rp) Harga Satuan (Rp)	Amount (Rp) Jmlah Harga (Rp)	Weight (%) Bobot (%)
1	**PEKERJAAN PERSIAPAN**					
1.8	Mobilisasi dan Demobilisasi	LS	1.00	350,520,000	350,520,000	0.09
1.9	Laporan dan Foto	LS	1.00	250,573,500	250,573,500	0.06
1.10	Direksi keet / Contractor's site office	LS	1.00	888,300,000	888,300,000	0.22
1.11	Keselamatan dan Kesehatan Kerja	LS/month	56.00	11,195,000	626,920,000	0.16
1.12	Covid-19 screening test, mitigation protocol and medical check-up	LS/month	56.00	45,602,500	2,553,740,000	0.64
1.13	Provision and maintence of project signs / Papan Nama Proyek	Set	4.00	1,030,400	4,121,600	0.00
				Sub Total - 1	**4,674,175,100**	**1.17**
2	**PEKERJAAN SALURAN PRIMER (L = 53.35 km)**					
2.1	Galian Tanah Biasa Tenaga Alat	m^3	1,267,460.59	55,800	70,724,300,916	17.66
2.2	Timbunan Tanah Setempat dipadatkan	m^3	505,179.58	103,200	52,134,532,315	13.02
2.3	Kupasan / Stripping of top soil	m^2	297,983.68	10,700	3,188,425,361	0.80
2.4	Gebalan Rumput	m^2	338,388.33	21,100	7,139,993,746	1.78
2.5	Backfill	m^3		59,200	-	-
2.6	Sub Base Course (Jalan Inspeksi)	m^2		160,200	-	-
2.7	Base Course	m^2		106,800	-	-
				Sub Total - 2	**133,187,252,339**	**33.26**
3	**PEKERJAAN SALURAN SEKUNDER (L = 41.53 km)**					
3.1	Galian Tanah Biasa Tenaga Alat	m^3	352,815.77	55,800	19,687,120,217	4.92
3.2	Timbunan Tanah Setempat dipadatkan	m^3	366,828.57	103,200	37,856,708,857	9.45
3.3	Kupasan / Stripping of top soil	m^2	315,451.94	10,700	3,375,335,708	0.84
3.4	Gebalan Rumput	m^2	223,563.80	21,100	4,717,196,098	1.18
3.5	Backfill	m^3		59,200	-	-
3.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
3.7	Base Course	m^3		106,800	-	-
				Sub Total - 3	**65,636,360,880**	**16.39**
4	**PEKERJAAN SALURAN DRAIN PRIMER (L = 29.19 km)**					
4.1	Galian Tanah Biasa Tenaga Alat	m^3	1,947,705.14	55,800	108,681,946,818	27.14
4.2	Timbunan Tanah Setempat dipadatkan	m^3	26,210.24	103,200	2,704,896,902	0.68
4.3	Kupasan / Stripping of top soil	m^2	73,449.83	10,700	785,913,176	0.20
4.4	Gebalan Rumput	m^2	217,714.62	21,100	4,593,778,569	1.15
4.5	Backfill	m^3		59,200	-	-
4.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
4.7	Base Course	m^3		106,800	-	-
				Sub Total - 4	**116,766,535,464**	**29.16**
5	**PEKERJAAN SALURAN DRAIN SEKUNDER (L = 53.61 km)**					
5.1	Galian Tanah Biasa Tenaga Alat	m^3	1,288,049.74	55,800	71,873,175,587	17.95
5.2	Timbunan Tanah Setempat dipadatkan	m^3	26,051.04	103,200	2,688,467,545	0.67
5.3	Kupasan / Stripping of top soil	m^2	76,499.15	10,700	818,540,862	0.20
5.4	Gebalan Rumput	m^2	226,478.14	21,100	4,778,688,853	1.19
5.5	Backfill	m^3		59,200	-	-
5.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
5.7	Base Course	m^3		106,800	-	-
				Sub Total - 5	**80,158,872,847**	**20.02**
6	**PEKERJAAN TEMPORARY COFFERDAM & DEWATERING**					
6.1	Temporary Cofferdam	LS	1.00	37,931,000	37,931,000	0.01
6.2	Dewatering (by pumping system) at all site	LS	-	-	-	-
				Sub Total - 6	**37,931,000**	**0.01**
7	**PEKERJAAN BANGUNAN INTAKE**					
7.1	Beton K-225	m^3		1,339,100	-	-
				Sub Total - 7	**-**	**-**
8	**PEKERJAAN STRUKTUR BANGUNAN**					
8.1	Talang	unit		28,750,150	-	-
8.2	Sipon	unit		75,515,325	-	-
8.3	Jembatan	unit		135,750,115	-	-
8.4	Jembatan Orang	unit		165,550,125	-	-
8.5	Gorong-gorong	unit		35,875,115	-	-
8.6	Pipa	unit		25,150,330	-	-
				Sub Total - 8	**-**	**-**

NO	WORKS ITEM / URAIAN PEKERJAAN			Unit / Satuan	Quantity / Volume	Unit Price (Rp) / Harga Satuan (Rp)	Amount (Rp) / Jmlah Harga (Rp)	Weight (%) / Bobot (%)
9	**PEKERJAAN PUMP STATION MECHANICAL & ELECTRICAL WORKS**							
9.1	Fix Wheel Gate	a)	b = 2,50 m ; h= 3,00 m	unit		441,340,000	-	-
		b)	b = 2,50 m ; h= 2,50 m	unit		433,930,000	-	-
		c)	b = 2,50 m ; h= 2,00 m	unit		426,390,000	-	-
9.2	Maintenance Stoplog	a)	b = 1,50 m ; h= 1,50 m	unit		62,160,000	-	-
		b)	b = 2,00 m ; h= 1,50 m	unit		72,560,000	-	-
		c)	b = 2,50 m ; h= 1,50 m	unit		75,810,000	-	-
9.3	Timber Stoplog	a)	b = 1,50 m ; h= 2,00 m	unit		42,010,000	-	-
		b)	b = 2,50 m ; h= 2,00 m	unit		49,550,000	-	-
		c)	b = 2,50 m ; h= 1,60 m	unit		43,700,000	-	-
9.4	Slide Gate - Manual	a)	1A (KP-Standard)	unit		56,890,000	-	-
		b)	1B (KP-Standard)	unit		62,480,000	-	-
		c)	2A (KP-Standard)	unit		57,930,000	-	-
		d)	2B (KP-Standard)	unit		63,520,000	-	-
		e)	2C (KP-Standard)	unit		59,750,000	-	-
		f)	3A (KP-Standard)	unit		65,730,000	-	-
		g)	3B (KP-Standard)	unit		73,530,000	-	-
		h)	3C (KP-Standard)	unit		79,900,000	-	-
		i)	4A (KP-Standard)	unit		67,940,000	-	-
		j)	4B (KP-Standard)	unit		75,740,000	-	-
		k)	5A (KP-Standard)	unit		87,850,000	-	-
		l)	6A (KP-Standard)	unit		93,050,000	-	-
		m)	7A (KP-Standard)	unit		100,980,000	-	-
9.5	Flat Gate			unit		117,880,000	-	-
9.6	Handpull Gate			unit		21,340,000	-	-
9.7	Trashrack	a)	b = 2,50 m ; h= 3,00 m	unit		86,040,000	-	-
		b)	b = 2,50 m ; h= 2,50 m	unit		77,850,000	-	-
		c)	b = 2,50 m ; h= 2,00 m	unit		69,660,000	-	-
9.8	Monorail Crane (Electric) 3T			unit		213,050,000	-	-
9.9	Monorail Crane (Manual) 3T			unit		72,780,000	-	-
9.10	Portal Crane (Manual) 3T			unit		130,240,000	-	-
9.11	Overhead Crane (Electric) 10T			unit		835,130,000	-	-
9.12	Monorail Crane (Electric) 5T			unit		252,960,000	-	-
9.13	Monorail Crane (Manual) 5T			unit		82,270,000	-	-
9.14	Lifting beam			unit		51,510,000	-	-
9.15	Trailer Pump 200 ls			unit		339,900,000	-	-
9.16	Trailer Pump 100 ls			unit		312,470,000	-	-
9.17	Trailer Pump 50 ls			unit		295,830,000	-	-
9.18	Trailer Pump 20 ls			unit		278,930,000	-	-
9.19	Fuel Storage Tank 50KL			unit		182,990,000	-	-
9.20	Fuel Storage Tank 25KL			unit		155,430,000	-	-
9.21	Fuel Storage Tank 10KL			unit		141,780,000	-	-
9.22	Fuel Storage Tank 5KL			unit		93,810,000	-	-
9.23	Fuel Storage Tank 1KL			unit		61,180,000	-	-
						Sub Total - 9	**0**	**-**
	TOTAL (1+2+3+4+5+6+7+8+9)						**400,461,127,630**	**100.00**
	VALUE ADDED TAX (10%) / PAJAK PERTAMBAHAN NILAI (10%) TIDAK DIPUNGUT							
	TOTAL / JUMLAH						**400,461,127,630**	
	ROUNDED / DIBULATKAN						**400,461,100,000**	
	SAYS: .... / TERBILANG:							

7.4 Engineering cost estimate of Package 3

ENGINEER'S COST ESTIMATES (EE)
HARGA PERKIRAAN PERENCANA (HPP)

WORKS	:	**Reconstruction of Merauke Main Canal, Secondary Canals and Drainage Canals (PACKAGE 3)**
PEKERJAAN	:	**Rekonstruksi Saluran Primer Merauke, Saluran Sekunder, dan Saluran Pembuang (PAKET 3)**
FISCAL YEAR	:	**2022-2026**
TAHUN ANGGARAN	:	**2022-2026**
PROJECT LOCATION	:	**Lower Jagebob, Sermayam, Merauke Regency, Papua Province**
LOKASI PROYEK	:	**Lower Jagebob, Sermayam, Kabupaten Merauke, Provinsi Papua**

NO	WORKS ITEM URAIAN PEKERJAAN	Unit Satuan	Quantity Volume	Unit Price (Rp) Harga Satuan (Rp)	Amount (Rp) Jmlah Harga (Rp)	Weight (%) Bobot (%)
1	**PEKERJAAN PERSIAPAN**					
1.8	Mobilisasi dan Demobilisasi	LS	1.00	350,520,000	350,520,000	0.08
1.9	Laporan dan Foto	LS	1.00	250,573,500	250,573,500	0.06
1.10	Direksi keet / Contractor's site office	LS	1.00	888,300,000	888,300,000	0.20
1.11	Keselamatan dan Kesehatan Kerja	LS/month	56.00	11,195,000	626,920,000	0.14
1.12	Covid-19 screening test, mitigation protocol and medical check-up	LS/month	56.00	45,602,500	2,553,740,000	0.57
1.13	Provision and maintence of project signs / Papan Nama Proyek	Set	4.00	1,030,400	4,121,600	0.00
				Sub Total - 1	**4,674,175,100**	**1.04**
2	**PEKERJAAN SALURAN PRIMER (L = 21.74 km)**					
2.1	Galian Tanah Biasa Tenaga Alat	m^3	1,276,521.06	55,800	71,229,874,981	15.90
2.2	Timbunan Tanah Setempat dipadatkan	m^3	90,112.80	103,200	9,299,641,063	2.08
2.3	Kupasan / Stripping of top soil	m²	64,844.25	10,700	693,833,515	0.15
2.4	Gebalan Rumput	m²	187,977.73	21,100	3,966,330,206	0.89
2.5	Backfill	m^3		59,200	-	-
2.6	Sub Base Course (Jalan Inspeksi)	m²		160,200	-	-
2.7	Base Course	m²		106,800	-	-
				Sub Total - 2	**85,189,679,765**	**19.01**
3	**PEKERJAAN SALURAN SEKUNDER (L = 54.67 km)**					
3.1	Galian Tanah Biasa Tenaga Alat	m^3	876,835.19	55,800	48,927,403,368	10.92
3.2	Timbunan Tanah Setempat dipadatkan	m^3	344,250.07	103,200	35,526,607,007	7.93
3.3	Kupasan / Stripping of top soil	m²	235,872.72	10,700	2,523,838,094	0.56
3.4	Gebalan Rumput	m²	359,017.46	21,100	7,575,268,360	1.69
3.5	Backfill	m^3		59,200	-	-
3.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
3.7	Base Course	m^3		106,800	-	-
				Sub Total - 3	**94,553,116,829**	**21.10**
4	**PEKERJAAN SALURAN DRAIN PRIMER (L= 16.11 km)**					
4.1	Galian Tanah Biasa Tenaga Alat	m^3	1,245,002.89	55,800	69,471,161,044	15.50
4.2	Timbunan Tanah Setempat dipadatkan	m^3	-	103,200	-	-
4.3	Kupasan / Stripping of top soil	m²	-	10,700	-	-
4.4	Gebalan Rumput	m²	154,329.25	21,100	3,256,347,084	0.73
4.5	Backfill	m^3		59,200	-	-
4.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
4.7	Base Course	m^3		106,800	-	-
				Sub Total - 4	**72,727,508,129**	**16.23**
5	**PEKERJAAN SALURAN DRAIN SEKUNDER (L = 43.88 km)**					
5.1	Galian Tanah Biasa Tenaga Alat	m^3	3,250,141.86	55,800	181,357,915,649	40.47
5.2	Timbunan Tanah Setempat dipadatkan	m^3	1,498.97	103,200	154,693,353	0.03
5.3	Kupasan / Stripping of top soil	m²	5,804.16	10,700	62,104,553	0.01
5.4	Gebalan Rumput	m²	442,552.01	21,100	9,337,847,495	2.08
5.5	Backfill	m^3		59,200	-	-
5.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
5.7	Base Course	m^3		106,800	-	-
				Sub Total - 5	**190,912,561,050**	**42.61**
6	**PEKERJAAN TEMPORARY COFFERDAM & DEWATERING**					
6.1	Temporary Cofferdam	LS	1.00	37,931,000	37,931,000	0.01
6.2	Dewatering (by pumping system) at all site	LS	-	-	-	-
				Sub Total - 6	**37,931,000**	**0.01**
7	**PEKERJAAN BANGUNAN INTAKE**					
7.1	Beton K-225	m^3		1,339,100	-	-
				Sub Total - 7	**-**	**-**
8	**PEKERJAAN STRUKTUR BANGUNAN**					
8.1	Talang	unit		28,750,150	-	-
8.2	Sipon	unit		75,515,325	-	-
8.3	Jembatan	unit		135,750,115	-	-
8.4	Jembatan Orang	unit		165,550,125	-	-
8.5	Gorong-gorong	unit		35,875,115	-	-
8.6	Pipa	unit		25,150,330	-	-
				Sub Total - 8	**-**	**-**

NO	WORKS ITEM / URAIAN PEKERJAAN			Unit / Satuan	Quantity / Volume	Unit Price (Rp) / Harga Satuan (Rp)	Amount (Rp) / Jmlah Harga (Rp)	Weight (%) / Bobot (%)
9	**PEKERJAAN PUMP STATION MECHANICAL & ELECTRICAL WORKS**							
9.1	Fix Wheel Gate	a)	b = 2,50 m ; h= 3,00 m	unit		441,340,000	-	-
		b)	b = 2,50 m ; h= 2,50 m	unit		433,930,000	-	-
		c)	b = 2,50 m ; h= 2,00 m	unit		426,390,000	-	-
9.2	Maintenance Stoplog	a)	b = 1,50 m ; h= 1,50 m	unit		62,160,000	-	-
		b)	b = 2,00 m ; h= 1,50 m	unit		72,560,000	-	-
		c)	b = 2,50 m ; h= 1,50 m	unit		75,810,000	-	-
9.3	Timber Stoplog	a)	b = 1,50 m ; h= 2,00 m	unit		42,010,000	-	-
		b)	b = 2,50 m ; h= 2,00 m	unit		49,550,000	-	-
		c)	b = 2,50 m ; h= 1,60 m	unit		43,700,000	-	-
9.4	Slide Gate - Manual	a)	1A (KP-Standard)	unit		56,890,000	-	-
		b)	1B (KP-Standard)	unit		62,480,000	-	-
		c)	2A (KP-Standard)	unit		57,930,000	-	-
		d)	2B (KP-Standard)	unit		63,520,000	-	-
		e)	2C (KP-Standard)	unit		59,750,000	-	-
		f)	3A (KP-Standard)	unit		65,730,000	-	-
		g)	3B (KP-Standard)	unit		73,530,000	-	-
		h)	3C (KP-Standard)	unit		79,900,000	-	-
		i)	4A (KP-Standard)	unit		67,940,000	-	-
		j)	4B (KP-Standard)	unit		75,740,000	-	-
		k)	5A (KP-Standard)	unit		87,850,000	-	-
		l)	6A (KP-Standard)	unit		93,050,000	-	-
		m)	7A (KP-Standard)	unit		100,980,000	-	-
9.5	Flat Gate			unit		117,880,000	-	-
9.6	Handpull Gate			unit		21,340,000	-	-
9.7	Trashrack	a)	b = 2,50 m ; h= 3,00 m	unit		86,040,000	-	-
		b)	b = 2,50 m ; h= 2,50 m	unit		77,850,000	-	-
		c)	b = 2,50 m ; h= 2,00 m	unit		69,660,000	-	-
9.8	Monorail Crane (Electric) 3T			unit		213,050,000	-	-
9.9	Monorail Crane (Manual) 3T			unit		72,780,000	-	-
9.10	Portal Crane (Manual) 3T			unit		130,240,000	-	-
9.11	Overhead Crane (Electric) 10T			unit		835,130,000	-	-
9.12	Monorail Crane (Electric) 5T			unit		252,960,000	-	-
9.13	Monorail Crane (Manual) 5T			unit		82,270,000	-	-
9.14	Lifting beam			unit		51,510,000	-	-
9.15	Trailer Pump 200 ls			unit		339,900,000	-	-
9.16	Trailer Pump 100 ls			unit		312,470,000	-	-
9.17	Trailer Pump 50 ls			unit		295,830,000	-	-
9.18	Trailer Pump 20 ls			unit		278,930,000	-	-
9.19	Fuel Storage Tank 50KL			unit		182,990,000	-	-
9.20	Fuel Storage Tank 25KL			unit		155,430,000	-	-
9.21	Fuel Storage Tank 10KL			unit		141,780,000	-	-
9.22	Fuel Storage Tank 5KL			unit		93,810,000	-	-
9.23	Fuel Storage Tank 1KL			unit		61,180,000	-	-
						Sub Total - 9	**0**	**-**
	TOTAL (1+2+3+4+5+6+7+8+9)						**448,094,971,872**	**100.00**
	VALUE ADDED TAX (10%) / PAJAK PERTAMBAHAN NILAI (10%) TIDAK DIPUNGUT							
	TOTAL / JUMLAH						**448,094,971,872**	
	ROUNDED / DIBULATKAN						**448,094,900,000**	
	SAYS: .... / TERBILANG:							

7.5 Engineering cost estimate of Package 4

ENGINEER'S COST ESTIMATES (EE)
HARGA PERKIRAAN PERENCANA (HPP)

WORKS	:	**Reconstruction of Merauke Main Canal, Secondary Canals and Drainage Canals (PACKAGE 4)**
PEKERJAAN	:	**Rekonstruksi Saluran Primer Merauke, Saluran Sekunder, dan Saluran Pembuang (PAKET 4)**
FISCAL YEAR	:	**2022-2026**
TAHUN ANGGARAN	:	**2022-2026**
PROJECT LOCATION	:	**Tanah Miring 2,4,7, Sidomulyo, Salor Kampung Kumbe Kampung, Merauke Regency,**
LOKASI PROYEK	:	**Tanah Miring 2,4,7, Sidomulyo, Salor Kampung Kumbe Kampung, Kabupaten**

NO	WORKS ITEM URAIAN PEKERJAAN	Unit Satuan	Quantity Volume	Unit Price (Rp) Harga Satuan (Rp)	Amount (Rp) Jmlah Harga (Rp)	Weight (%) Bobot (%)
1	**PEKERJAAN PERSIAPAN**					
1.8	Mobilisasi dan Demobilisasi	LS	1.00	350,520,000	350,520,000	0.13
1.9	Laporan dan Foto	LS	1.00	250,573,500	250,573,500	0.10
1.10	Direksi keet / Contractor's site office	LS	1.00	888,300,000	888,300,000	0.34
1.11	Keselamatan dan Kesehatan Kerja	LS/month	56.00	11,195,000	626,920,000	0.24
1.12	Covid-19 screening test, mitigation protocol and medical check-up	LS/month	56.00	45,602,500	2,553,740,000	0.97
1.13	Provision and maintence of project signs / Papan Nama Proyek	Set	4.00	1,030,400	4,121,600	0.00
				Sub Total - 1	**4,674,175,100**	**1.78**
2	**PEKERJAAN SALURAN PRIMER (L = 41.57 km)**					
2.1	Galian Tanah Biasa Tenaga Alat	m^3	1,821,441.13	55,800	101,636,415,327	38.65
2.2	Timbunan Tanah Setempat dipadatkan	m^3	2,791.89	103,200	288,122,811	0.11
2.3	Kupasan / Stripping of top soil	m^2	10,837.75	10,700	115,963,954	0.04
2.4	Gebalan Rumput	m^2	279,373.64	21,100	5,894,783,905	2.24
2.5	Backfill	m^3		59,200	-	-
2.6	Sub Base Course (Jalan Inspeksi)	m^2		160,200	-	-
2.7	Base Course	m^2		106,800	-	-
				Sub Total - 2	**107,935,285,997**	**41.04**
3	**PEKERJAAN SALURAN SEKUNDER (L = 28.02 km)**					
3.1	Galian Tanah Biasa Tenaga Alat	m^3	109,134.47	55,800	6,089,703,253	2.32
3.2	Timbunan Tanah Setempat dipadatkan	m^3	243,492.74	103,200	25,128,450,252	9.55
3.3	Kupasan / Stripping of top soil	m^2	210,055.33	10,700	2,247,592,056	0.85
3.4	Gebalan Rumput	m^2	120,327.53	21,100	2,538,910,780	0.97
3.5	Backfill	m^3		59,200	-	-
3.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
3.7	Base Course	m^3		106,800	-	-
				Sub Total - 3	**36,004,656,340**	**13.69**
4	**PEKERJAAN SALURAN DRAIN PRIMER (L = 20.98 km)**					
4.1	Galian Tanah Biasa Tenaga Alat	m^3	969,674.01	55,800	54,107,809,752	20.57
4.2	Timbunan Tanah Setempat dipadatkan	m^3	-	103,200	-	-
4.3	Kupasan / Stripping of top soil	m^2	12.55	10,700	134,285	0.00
4.4	Gebalan Rumput	m^2	141,841.95	21,100	2,992,865,088	1.14
4.5	Backfill	m^3		59,200	-	-
4.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
4.7	Base Course	m^3		106,800	-	-
				Sub Total - 4	**57,100,809,125**	**21.71**
5	**PEKERJAAN SALURAN DRAIN SEKUNDER (L = 32.03 km)**					
5.1	Galian Tanah Biasa Tenaga Alat	m^3	942,268.75	55,800	52,578,596,468	19.99
5.2	Timbunan Tanah Setempat dipadatkan	m^3	10,804.53	103,200	1,115,027,929	0.42
5.3	Kupasan / Stripping of top soil	m^2	38,016.97	10,700	406,781,622	0.15
5.4	Gebalan Rumput	m^2	148,717.42	21,100	3,137,937,659	1.19
5.5	Backfill	m^3		59,200	-	-
5.6	Sub Base Course (Jalan Inspeksi)	m^3		160,200	-	-
5.7	Base Course	m^3		106,800	-	-
				Sub Total - 5	**57,238,343,678**	**21.76**
6	**PEKERJAAN TEMPORARY COFFERDAM & DEWATERING**					
6.1	Temporary Cofferdam	LS	1.00	37,931,000	37,931,000	0.01
6.2	Dewatering (by pumping system) at all site	LS	-	-	-	-
				Sub Total - 6	**37,931,000**	**0.01**
7	**PEKERJAAN BANGUNAN INTAKE**					
7.1	Beton K-225	m^3		1,339,100	-	-
				Sub Total - 7	**-**	**-**
8	**PEKERJAAN STRUKTUR BANGUNAN**					
8.1	Talang	unit		28,750,150	-	-
8.2	Sipon	unit		75,515,325	-	-
8.3	Jembatan	unit		135,750,115	-	-
8.4	Jembatan Orang	unit		165,550,125	-	-
8.5	Gorong-gorong	unit		35,875,115	-	-
8.6	Pipa	unit		25,150,330	-	-
				Sub Total - 8	**-**	**-**

NO	WORKS ITEM / URAIAN PEKERJAAN			Unit / Satuan	Quantity / Volume	Unit Price (Rp) / Harga Satuan (Rp)	Amount (Rp) / Jmlah Harga (Rp)	Weight (%) / Bobot (%)
9	**PEKERJAAN PUMP STATION MECHANICAL & ELECTRICAL WORKS**							
9.1	Fix Wheel Gate	a)	b = 2,50 m ; h= 3,00 m	unit		441,340,000	-	-
		b)	b = 2,50 m ; h= 2,50 m	unit		433,930,000	-	-
		c)	b = 2,50 m ; h= 2,00 m	unit		426,390,000	-	-
9.2	Maintenance Stoplog	a)	b = 1,50 m ; h= 1,50 m	unit		62,160,000	-	-
		b)	b = 2,00 m ; h= 1,50 m	unit		72,560,000	-	-
		c)	b = 2,50 m ; h= 1,50 m	unit		75,810,000	-	-
9.3	Timber Stoplog	a)	b = 1,50 m ; h= 2,00 m	unit		42,010,000	-	-
		b)	b = 2,50 m ; h= 2,00 m	unit		49,550,000	-	-
		c)	b = 2,50 m ; h= 1,60 m	unit		43,700,000	-	-
9.4	Slide Gate - Manual	a)	1A (KP-Standard)	unit		56,890,000	-	-
		b)	1B (KP-Standard)	unit		62,480,000	-	-
		c)	2A (KP-Standard)	unit		57,930,000	-	-
		d)	2B (KP-Standard)	unit		63,520,000	-	-
		e)	2C (KP-Standard)	unit		59,750,000	-	-
		f)	3A (KP-Standard)	unit		65,730,000	-	-
		g)	3B (KP-Standard)	unit		73,530,000	-	-
		h)	3C (KP-Standard)	unit		79,900,000	-	-
		i)	4A (KP-Standard)	unit		67,940,000	-	-
		j)	4B (KP-Standard)	unit		75,740,000	-	-
		k)	5A (KP-Standard)	unit		87,850,000	-	-
		l)	6A (KP-Standard)	unit		93,050,000	-	-
		m)	7A (KP-Standard)	unit		100,980,000	-	-
9.5	Flat Gate			unit		117,880,000	-	-
9.6	Handpull Gate			unit		21,340,000	-	-
9.7	Trashrack	a)	b = 2,50 m ; h= 3,00 m	unit		86,040,000	-	-
		b)	b = 2,50 m ; h= 2,50 m	unit		77,850,000	-	-
		c)	b = 2,50 m ; h= 2,00 m	unit		69,660,000	-	-
9.8	Monorail Crane (Electric) 3T			unit		213,050,000	-	-
9.9	Monorail Crane (Manual) 3T			unit		72,780,000	-	-
9.10	Portal Crane (Manual) 3T			unit		130,240,000	-	-
9.11	Overhead Crane (Electric) 10T			unit		835,130,000	-	-
9.12	Monorail Crane (Electric) 5T			unit		252,960,000	-	-
9.13	Monorail Crane (Manual) 5T			unit		82,270,000	-	-
9.14	Lifting beam			unit		51,510,000	-	-
9.15	Trailer Pump 200 ls			unit		339,900,000	-	-
9.16	Trailer Pump 100 ls			unit		312,470,000	-	-
9.17	Trailer Pump 50 ls			unit		295,830,000	-	-
9.18	Trailer Pump 20 ls			unit		278,930,000	-	-
9.19	Fuel Storage Tank 50KL			unit		182,990,000	-	-
9.20	Fuel Storage Tank 25KL			unit		155,430,000	-	-
9.21	Fuel Storage Tank 10KL			unit		141,780,000	-	-
9.22	Fuel Storage Tank 5KL			unit		93,810,000	-	-
9.23	Fuel Storage Tank 1KL			unit		61,180,000	-	-
						Sub Total - 9	**0**	**-**
	TOTAL (1+2+3+4+5+6+7+8+9)						**262,991,201,241**	**100.00**
	VALUE ADDED TAX (10%) / PAJAK PERTAMBAHAN NILAI (10%) TIDAK DIPUNGUT							
	TOTAL / JUMLAH						**262,991,201,241**	
	ROUNDED / DIBULATKAN						**262,991,200,000**	
	SAYS: .... / TERBILANG:							

8 Conclusions and recommendations

8.1 Conclusions

8.1.1 Lowland irrigation system

The proposed development of the lowland irrigation will improve the water services for the agriculture practice in the phase 1 area. Taking into account the hydrological and hydro-topographic conditions, soil conditions, socio-economic and environmental conditions, it is concluded that the lowland irrigation development in Merauke District, Papua, technically can be developed economically and effectively.

For the most part the supply of irrigation water is during the second crop when the main sources of water are in the Kumbe and Maro rivers. In some near coastal areas the salinity in the rivers cannot be used to irrigate the present crops grown on the scheme. Whilst the main rivers will provide the main source of irrigation water during dry periods it should be augmented by drainage and surface stored water. As these sources can be stored at higher levels that river water they should be used as a priority when available. The development of the lowland irrigation in that area using this approach with drainage cum storage, means that the development of lowland irrigation is by good complementary management of both sources of water. For the near coastal areas to multi-crop into the dry season they will depend on the good water management passed down from upstream network areas. Here the utilization of water in the conservation /drainage canals actually play a big role of the water service of the field. In addition, pilot areas are proposed to better adapt to increased salinity in such areas using more salinity resilient crops, integrated use of groundwater, natural salinity reduction algae and solar desalination.

For both water provision efforts, the major problem is about the level difference of water source and the field levels as the water levels are always below the field levels. The only solution is to lift water, either from supply canals or from the conservation /drainage canals to the field. Studies have shown that generally it is most effective to use main and primary canals for river entry storage and pump into secondary canals to ensure sufficient water reaches the ends of lower order collector canals. Water service through the secondary supply canals will be provided by the government. The operators then have the flexibility to choose to: (i) pump to service levels to provide gravity flow to all or some of the farmers, or (ii) pump to an agreed level and maintain at that level with the farmers pumping from that level into the fields; or (iii) pumping to a set level with farmers pumping from it for several days until a critical level is reached in the collector or secondary canal at which point the secondary pumps will refill the canals.

From the farmers side, an effort to utilize water from the conservation /drainage canals to the tertiaries is carried by farmers themselves using individual pumps or collective pump for the P3A area.

The total development area in phase 1 is about 25,000 ha, and in phase 2 is 25,000 ha will be using the same approach[6]. However, the detailed design only covers the first phase.

Pump stations in the supply system is usually located at the division structures from primary canals to secondary canals. An exception is where a tertiary area is supplied directly from a main or primary canal. Those pumps are designed to operate about 10 hours in a day when needed. There will be more than two pumps at one station, to make it flexible when should provide service discharge.

The pump location for farmers depends on the particular scheme layout. For Kurik it is located along the main drainage /conservation canals, to deliver water to their supply tertiaries, and water flows to the field by gravity. On Salor there is a culvert at the end of the secondary, or key point on a secondary, with a flap gate that prevents loss from the canal into the drain but admits water when the level in the drain is higher than in the secondary,

[6] The Kumbe dam will be studied during Phase 1 which will allow most of the Kumbe command area to be irrigated by gravity.

Considering the land slope is very flat, and consequently the flow gradient of the canals which are oversized to provide storage. Initially the canals were designed following the KP-03 guidelines which resulted in very small canals even when design flows were doubled to represent 12 hour pumping. Since then they have been redesigned to fit the existing oversized profiles.

For upslope areas where pumping over 5m in elevation is required such as at Lower Jagebob and Salor 2, and 4 and a part of Salor 3, the pump capacities have been sized to supply irrigated palawija. This still allows a combined mainly rainfed wet season rice to be grown and augmented by pumping if needed.

8.1.2 Protection from flooding (water damaging power)

To protect the land from the damaging power of water (flooding), a 72 km long dike is planned along the border between the lowland irrigation areas with the open water /river[7]. The flood embankment can also be used for land transportation, so that each adjoining unit can be connected.

To reduce the flood water in the irrigation areas from internal drainage it is planned to improve the drainage system including construction outlet structures along the alignment of the flood bank. During the wet season excess flows will be discharged into the river and at the same time to stop flood water from river, the during wet seasons.. During the dry season they will be closed by stoplogs to allow water levels to build up behind they to augment irrigation flows. In fact they will be at a higher level and used, when available, as a priority to reduce secondary canal pumping. Generally they can retain drain water to an elevation up to 3 mOD. Water that enters the drainage /conservation canals at that time cannot flows back to the river.

8.1.3 Transportation network

The proposed transportation network is a combination of water transportation along the primary, as well as land transportation to connect the subprojects with the Production Processing Center. Inspection roads along primary canals, secondaries and drainage /conservation canals can perform as a transportation network for farm level transport but not for major sized trucks. The flood protection dikes along the lowland area performs as transportation network as well.

8.2 Recommendations

The prerequisite for the development of the lowland irrigation areas in Merauke for Phase 1 and 2 is to carry out improvement the major supply canals, including the intake structures, as well as the drainage /conservation canals and its related structures as the first priority.

The second priority would be to build secondary supply canals. When it is completed, the collector block and canals can be implemented as the third priority.

The effort to reduce the damage of destruction power of water, flood protection dikes should also be implemented as the third priority as well. Although this is important, however, it can wait until the whole main canal system development almost completed. At that time it will be known whether to proceed in Kumbe with the Kumbe Dam which will obviate the need for some 67 km of the flood embankments due to the major flood retention capacity.

After the physical construction is completed, it must be followed by the operation and maintenance of the infrastructure. It takes a special institution that handles the OP activities of this lowland irrigation development intensively. Operations and maintenance must be carried out systematically, in accordance with environmental conditions, using appropriate technology, carried out by adequate human resources. There needs to be an increase in providing water services capacity, particularly at the boundary between the operator and the WUAs.

[7] Note that if the Kumbe Dam FS in phase 1 is economic only some 5 km of flood embankment is required at a lower elevation.

Appendices

Appendix A: Comment and response matrix

Appendix B: Derivation of irrigation water requirements

Appendix C: Flood protection design

Appendix D: Canal design

Appendix E: Structure design

Appendix F: Pump station design

Appendix G: Layout Plan and Schematic Diagram

Appendix H: Design drawings

Appendix I: Bill of quantities

Appendix A. Comment and Response Matrix

In this Appendix we present the comments and suggestions received during an online discussion of the final draft version of the DED Report on date 11 March 2022 and 22 March 2022, together with our response and whether (and how) we have adjusted our Inception Report. We hope that this will facilitate the Client's approval of this report.

Table 8-1 Comment and response matrix for finalisation of the Inception Report

Comment from		Comment	Response by Consultant	Location
Bistok Sigalingging	1.1	Seberapa besar peranan intake Kumbe terhadap pengisian air di saluran air primer ini?	Intake Kumbe mendukung kebutuhan air untuk musim tanam II dan III.	
	1.2	Jadi dalam system ini, ada atau tidak waduk Efata system tetap berjalan?jadi perlu dibuat skema titik-titik.	Pompa yang ada pada waduk galian Efata nantinya akan digunakan untuk mengaliri ke pompa poma sekunder yang lainnya.	
	1.3	Waduk Efata tetap digambar dalam skema dengan tambahan keterangan opsional.		
	1.4	Karena Waduk Efata bisa dikeluarkan dari system,dan difokuskan sebagai penyedia air baku, maka O&Pnya juda dinyatakan sebagai air baku.		
	1.5	Berapa daya tampung saluran yang akan diperbesar?		
Mezaac Elias Tomasila	2.1	Dalam peta ini terkoneksi waduk gali Efata, apakah sistem ini termasuk untuk pengisian waduk tersebut?		
	2.2	Waduk gali Efata digunakan untuk penyedia air baku.	Kami setuju, waduk Efata dijadikan penyedia air baku.	
	2.3	Dalam laporan ini seharusnya tergabung perencanaan yang sudah dibuat oleh BWS dan perencanaan yang akan dibuat oleh ESP. Kenapa dalam penjelasan ini, tidak dijadikan satu kesatuan dengan sistem yang sudah dikembangkan oleh BWS?	Nantinya saluran-saluran yang sedang dikerjakan sekarang akan diteruskan ke saluran-saluran yang sudah direncakan oleh BWS Papua Merauke.	
	2.4	Dalam penjelasan sistem jaringan primer tidak ada perlakuan khusus terhadap sistem jaringan sekunder. Apakah volume tampungan ini sudah cukup memenuhi kebutuhan selama 1 musim tanam? apakah sudah dihitung volume tampungannya?	Jika dianggap lebar bawah saluran 2 meter dan kedalaman 2 meter sehingga luas penampang 8 meter. Jika Panjang sampai 1000 m. Volume air paling banyak untuk 7 hari.	
	2.5	Apa sistem yang digunakan, long storage atau pengambilan? (untuk Kuprik Sidomulyo)	Sistem yang digunakan adalah sistem long storage	
	2.6	Apakah saat musim hujan kelebihan air hujan dibuang atau ditampung?	Garis warna merah dan biru adalah aliran sungai yang nantinya akan ditampungkan air hujan.	
	2.7	Apakah sudah dihtung curah hujan yang ada dengan volume tampungannya sudah mencukupi atau belum? jika persediaan air hanya untuk 6 hari, apa yang dilakukan untuk menutupi kekurangannya?	Untuk curah hujan sudah mencukupi tetapi tampungannya setelah dihitung ada persediaan 1,5 juta kubik.	
	2.8	Dari survey kemarin, ini potensinya ke pertanian atau ke perkebunan supaya sistem jaringannya menyesuaikan? (untuk lower jagebob)	Musim tanam untuk di Jagebob adalah palawija dan padi.	
	2.9	Ini saluran primer berada di Kampung Poo yang merupakan kampung OAP. Apakah ini tidak akan menimbulkan konflik karena saluran akan digunakan untuk masyarakat tranmigrasi.		

Comment from		Comment	Response by Consultant	Location
	2.10	Jalan inpeksi tidak perlu dari beton melainkan dari semen.		
	2.11	Untuk pembuatan tanggul harap ditampilkan lokasi dan darimana materialnya?karena menyangkut biaya.		
	2.12	Saya sarankan, kita membuat tanggul dengan memakai material setempat saja.		
	2.13	Untuk Kurik, sebaiknya terase yang kita rencanakan melewati jalur alam daripada harus melewati fasilitas umum karena akan lebih rumit.		
	2.14	Apabila susah untuk merubah saluran, maka harus dijelaskan dalam laporan apa saja yang harus dipindakan dan catatan tanda bahaya atas kedalaman saluran, karena hal ini menyangkut biaya.		
	2.15	Dolken bangunan air yang digunakan diameter 15-20cm dan sangat melimpah		
Hartoyo Supriyanto	3.1	Mohon ditegaskan dulu dari sistem cropping pattern untuk dijadikan dasar sistem.		
	3.2	Untuk sistem irigasi PMI walaupun ini pilot project, karena ini sudah level On Farm sehingga ini kewenangan dari Kementrian Pertanian. Sehingga kita perlu mempertimbangkan dari segi kewenangan.		
Ferdinand Pakpahan	4.1	Jika melihat diameter dolken 15cm sudah seperti tiang pancang hanya terbuat dari kayu. Itu daya dukung tanah terhadap besaran dolken dan jaraknya harus dihitung sehingga ekonomis. Ini menyangkut biaya konstruksinya. Mohon dicek.		
	4.2	Untuk embankment ditambahkan bermnya.		
	4.3	Apakah ada bangunan talang?	Tidak ada bangunan talang.	
	4.4	Untuk materialnya menggunakan slow banking method bukan pre loading.		
	4.5			
Paulus Thoban	5.1	Dalam gambar design, ini letak timbunan salah bisa longsor dan ada celah untuk genangan air.		
	5.2	Hasil galian akan diletakkan dimana?		

Appendix B. Derivation of Irrigation Water Requirement

The water requirement in paddy fields for rice is determined by the following factors:

1. Land Preparation
2. Consumptive Evapotranspiration
3. Percolation
4. Water Layer Replacement
5. Effective Rainfall

The total water requirement in paddy fields covers factors 1 to 5. The net water requirement in paddy fields (NFR) also consider the effective rainfall. The paddy water requirement in the fields is expressed in mm/day or l/s/ha and can be calculated by the following formula:

$$NFR = LP + Eo + P + WLR - Re$$

Where:

NFR = Net Field Requirement (mm/day)

LP = Land Preparation (mm/day)

Etc = Consumptive Evapotranspiration (mm/day)

P = Percolation (mm/day)

WLR = Water Layer Replacement (mm/day)

Re = Effective Rainfall (mm/day)

A.1 Land Preparation

Water is needed during the land preparation phase to facilitate ploughing and prepare soil moisture for paddy growth. In calculating the value of land preparation, the Van de Goor / Zijlstra (1968) method will be used. The method is based on the water requirement to replace water loss due to evaporation and percolation in the paddy fields, which have been saturated during the land preparation period, with the required inundation height. The average value for Indonesia is obtained based on the following equation:

$$LP = \frac{Me^k}{e^k - 1}$$ [8]

Where:

LP = Land Preparation (mm/day)

M = Water requirement to replace/compensate for water loss due to evaporation and percolation in saturated rice fields M = Eo + P (mm/day)

Eo = 1,1 x ETo (mm/day)

P = Percolation

k = MT/S

T = Land preparation period (day)

S = Water inundation needed (mm)

[8] Standart Perencanaan Irigasi- KP-01 Perencanaan Jaringan Irigasi

The results of land preparation calculations can be seen in the table below.

Table A. 1 Land preparation calculation

Month	Days	Basic Data								
		ETo	P	Reff	Eo = ETo * 1.1	M = Eo + P	T	S	K = M * T / S	LP = M * ek / (ek -1)
		1	2	3	4	5	6	7	8	9
		(mm/day)	(mm/day)	(mm/day)	(mm/day)	(mm/day)	day	mm		(mm/day)
Jan	15	3.78	3.00	1.96	4.16	7.16	60	300	1.43	9.41
	16	3.68	3.00	4.07	4.05	7.05	60	300	1.41	9.33
Feb	14	3.57	3.00	3.08	3.93	6.93	60	300	1.39	9.24
	14	3.47	3.00	3.75	3.82	6.82	60	300	1.36	9.16
Mar	15	3.38	3.00	4.90	3.72	6.72	60	200	2.01	7.75
	16	3.28	3.00	2.82	3.61	6.61	60	200	1.98	7.66
Apr	15	3.26	3.00	2.39	3.59	6.59	60	200	1.98	7.65
	15	3.25	3.00	1.22	3.58	6.58	60	200	1.97	7.64
May	15	3.25	3.00	0.42	3.58	6.58	60	200	1.97	7.64
	16	3.24	3.00	0.25	3.56	6.56	60	200	1.97	7.63
Jun	15	3.23	3.00	0.06	3.56	6.56	60	200	1.97	7.62
	15	3.23	3.00	0.20	3.55	6.55	60	200	1.97	7.62
Jul	15	3.25	3.00	0.09	3.57	6.57	60	200	1.97	7.64
	16	3.39	3.00	0.03	3.73	6.73	60	200	2.02	7.76
Aug	15	3.73	3.00	-	4.10	7.10	60	200	2.13	8.06
	16	4.13	3.00	-	4.54	7.54	60	200	2.26	8.42
Sep	15	4.58	3.00	-	5.03	8.03	60	200	2.41	8.83
	15	4.83	3.00	-	5.31	8.31	60	200	2.49	9.06
Oct	15	4.96	3.00	-	5.46	8.46	60	200	2.54	9.19
	16	5.03	3.00	-	5.53	8.53	60	200	2.56	9.25
Nov	15	4.99	3.00	-	5.49	8.49	60	200	2.55	9.21
	15	4.80	3.00	-	5.27	8.27	60	200	2.48	9.03
Des	15	4.41	3.00	0.32	4.85	7.85	60	200	2.35	8.67
	16	4.12	3.00	1.24	4.53	7.53	60	200	2.26	8.41

A.2 Evaporation and Consumptive Evapotranspiration

Consumptive evapotranspiration is the amount of water needed to replace water lost due to evaporation from the leaves of plants during photosynthesis. During land preparation and early plant development of rice crops, water is also lost due to evaporation. As the leaves of the plants develop, evapotranspiration increases and evaporation decreases. Consumptive use is the actual water demand. Consumptive use is the combination of both and calculated by the equation:

$$ETc = kc \ x \ ETo$$

Where:

ETc = Consumptive Evapotranspiration (mm/day)

ETo = Potential Evapotranspiration (mm/day), calculated using Penman Method

kc = Plant coefficient

The plant coefficient values used in the calculation can be seen in the table below.

Table A. 2 Plant coefficient

Rice Time Period Coefficients			
Time period	**H.Y.V Crop values from Cropwat**	**Palawija crop**	**Fruit + veg continuous**
TP1	LP		
TP2	LP		
TP3	1.20		
TP4	1.16	0.7	0.91
TP5	1.06	0.75	0.91
TP6	0.97	0.88	0.91
TP7	0.69	0.91	0.91
TP8	0.23	0.91	0.91
TP9	0.00	0.82	0.91
		0.41	0.91

A.3 Percolation

The rate of percolation is very dependent on the properties of the soil. In heavy clay soils with good puddling characteristics, the percolation rate can reach 1-3 mm/day. In the calculation, a percolation value of 3 mm/day is used.

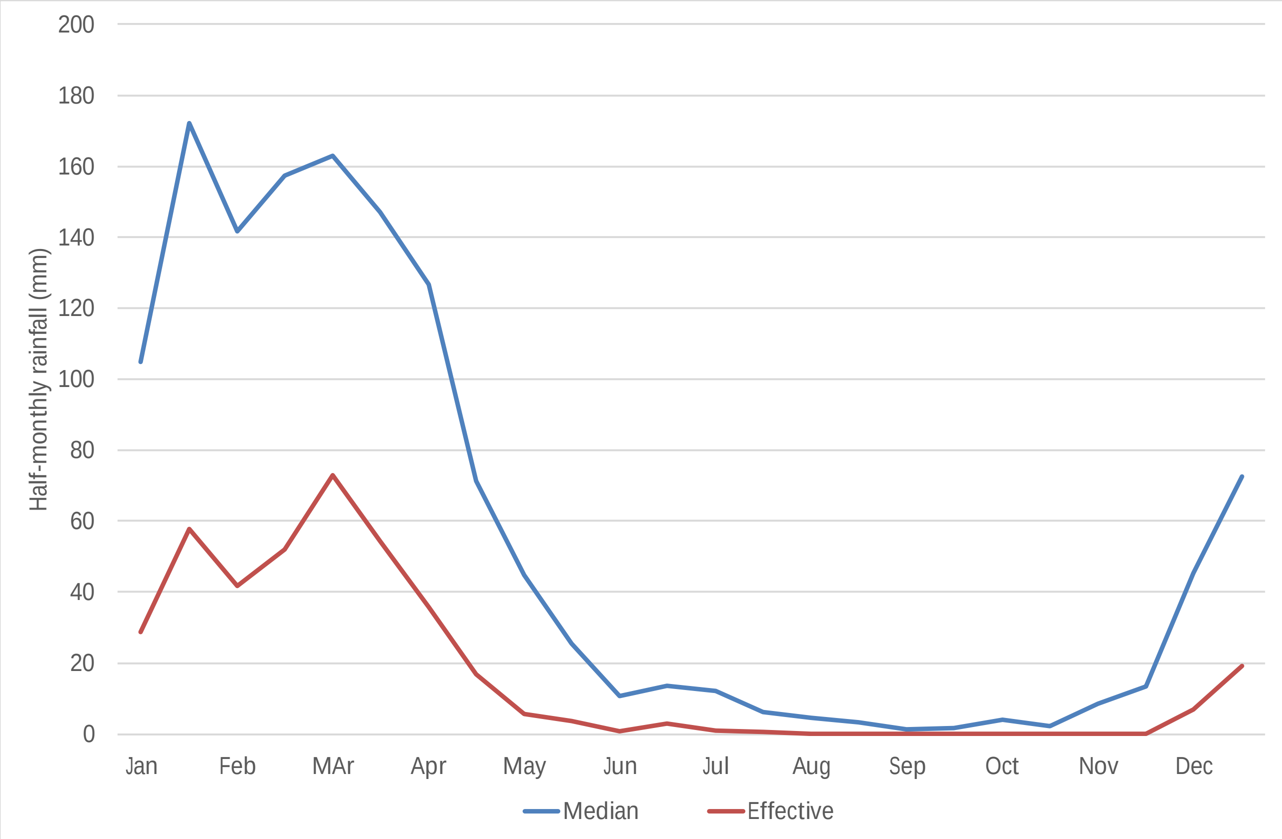
A.4 Water Layer Replacement

When producing rice, for fertilization and for weeding, the practice of lowering the water level in the fields is used. Based on this treatment the water layer must be replaced. The value of water layer replacement is 50 mm (3.33 mm/day) every third and fifth half-month. This requirement does not apply to palawija crops due to different cultural practices.

A.5 Effective Rainfall

For irrigation, the standard approach for this in Indonesia is to adopt 70% of the 1-in-5 year (i.e., 80% reliable) half-monthly rainfall. Detailed calculations for effective rainfall have been fully discussed in the hydrology report. The value of effective rainfall can be seen in the graph below.

Figure A.1 Effective Rainfall



A.6 Net Field Requirement

In addition, the factors above, the results of irrigation requirement value in the fields depend on the cropping pattern and the beginning of the planting period. In the calculation, we calculate the irrigation requirement with cropping pattern of Paddy-Paddy-Palawija and Paddy-Palawija-Palawija depend on the elevation of irrigation area. Each cropping pattern will be calculated with the planting period starting in December and January. Calculations can be seen from the table below.

Figure A.2 NFR calculation for Paddy-Paddy-Palawija (Start in December)

Item			Des		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
			15	16	15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15
Basic Data																										
Eto (1)		(mm/day)	4.41	4.12	3.78	3.68	3.57	3.47	3.38	3.28	3.26	3.25	3.25	3.24	3.23	3.23	3.25	3.39	3.73	4.13	4.58	4.83	4.96	5.03	4.99	4.80
Percolation, P (2)		(mm/day)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Reff (3)		(mm/day)	0.32	1.24	1.96	4.07	3.08	3.75	4.90	2.82	2.39	1.22	0.42	0.25	0.06	0.20	0.09	0.03	-	-	-	-	-	-	-	-
Eo = Eto * 1.1 (4)		(mm/day)	4.85	4.53	4.16	4.05	3.93	3.82	3.72	3.61	3.59	3.58	3.58	3.56	3.56	3.55	3.57	3.73	4.10	4.54	5.03	5.31	5.46	5.53	5.49	5.27
M = Eo + P (5)		(mm/day)	7.85	7.53	7.16	7.05	6.93	6.82	6.72	6.61	6.59	6.58	6.58	6.56	6.56	6.55	6.57	6.73	7.10	7.54	8.03	8.31	8.46	8.53	8.49	8.27
T (6)		day	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
S (7)		mm	300.00	300.00	300.00	300.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
K = M * T / S (8)			1.57	1.51	1.43	1.41	2.08	2.05	2.01	1.98	1.98	1.97	1.97	1.97	1.97	1.97	1.97	2.02	2.13	2.26	2.41	2.49	2.54	2.56	2.55	2.48
LP = M * e^k / (e^k -1) (9)		(mm/day)	9.91	9.68	9.41	9.33	7.92	7.83	7.75	7.66	7.65	7.64	7.64	7.63	7.62	7.62	7.64	7.76	8.06	8.42	8.83	9.06	9.19	9.25	9.21	9.03
Cropping Pattern																										
				LP				Paddy			Ripen		LP			Paddy			Ripen				Palawija/Jagung		Ripen	
Crop Coef. Kc :																										
- Wet season paddy (kc)					1.20	1.16	1.06	0.97	0.69	0.23	0.00															
						1.20	1.16	1.06	0.97	0.69	0.23	0.00														
Area factor					0.25	0.50	0.50	0.50	0.50	0.25																
						0.25	0.50	0.50	0.50	0.50	0.25															
Kc with Area Factor (paddy)					0.30	0.88	1.11	1.02	0.83	0.40	0.06	-														
- Dry season paddy (kc)													1.20	1.16	1.06	0.97	0.69	0.23	0.00							
														1.20	1.16	1.06	0.97	0.69	0.23	0.00						
area factor													0.25	0.50	0.50	0.50	0.50	0.25								
														0.25	0.50	0.50	0.50	0.50	0.25							
Kc with Area Factor (paddy)													0.30	0.88	1.11	1.02	0.83	0.40	0.06	-						
Palawija (kc)																			0.70	0.75	0.88	0.91	0.91	0.82	0.41	
																				0.70	0.75	0.88	0.91	0.91	0.82	0.41
Area factor																			0.25	0.50	0.50	0.50	0.50	0.25		
																				0.25	0.50	0.50	0.50	0.50	0.25	
Kc with Area Factor (palawija)																			0.18	0.55	0.82	0.90	0.91	0.66	0.21	-
Land Preparation LP	LP = Σ (RL) . [10]																									
- Wet season paddy			9.91	9.68																						
Area Factor			0.25	0.75																						
LP with Area Factor			2.48	7.26																						
- Dry season paddy (kc)																										
											7.65	7.64														
Area Factor											0.25	0.75														
LP with Area Factor											1.91	5.73														
Consumptive use ETc with Area Factor	ETc = Σ (Kc . RL) . ETo	(mm/day)																								
- Wet season paddy			-	-	1.13	3.24	3.97	3.52	2.80	1.32	0.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy										-	-	-	0.98	2.85	3.59	3.28	2.70	1.36	0.21	-	-	-	-	-	-	-
- Palawija			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	2.27	3.73	4.32	4.52	3.32	1.02	-
Percolation with Area Factor																										
- Wet season paddy		(mm/day)			0.75	2.25	3.00	3.00	3.00	2.25	0.75	-														
- Dry season paddy		(mm/day)											0.75	2.25	3.00	3.00	3.00	2.25	0.75	-						
- Palawija		(mm/day)																								
Water Layer Replacement	W = 50 / n																									
- Wet season paddy (kc)							3.33		3.33																	
								3.33		3.33																
	Area Factor				0.25	0.50	0.50	0.50	0.50	0.25																
						0.25	0.50	0.50	0.50	0.50	0.25															
	WLR with Area Factor						1.67	1.67	1.67	1.67	-	-	-													
- Dry season paddy (kc)															3.33		3.33									
																3.33		3.33								
	Area Factor												0.25	0.50	0.50	0.50	0.50	0.25								
														0.25	0.50	0.50	0.50	0.50	0.25							
	WLR with Area Factor														1.67	1.67	1.67	1.67	-	-	-					
NFR																										
- Wet season paddy	q = LP + ETc + P + W - R_{eff}	(mm/day)	2.16	6.02	-	1.42	5.55	4.44	2.57	2.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy		(mm/day)	-	-	-	-	-	-	-	-	-	4.51	1.31	4.85	8.20	7.74	7.27	5.25	0.96	-	-	-	-	-	-	-
- Palawija		(mm/day)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	2.27	3.73	4.32	4.52	3.32	1.02	-
- Wet season paddy		(l /s/ha)	0.25	0.70	-	0.16	0.64	0.51	0.30	0.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy		(l /s/ha)	-	-	-	-	-	-	-	-	-	0.52	0.15	0.56	0.95	0.90	0.84	0.61	0.11	-	-	-	-	-	-	-
- Palawija		(l /s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.26	0.43	0.50	0.52	0.38	0.12	-
Total		(l /s/ha)	0.25	0.70	-	0.16	0.64	0.51	0.30	0.28	-	0.52	0.15	0.56	0.95	0.90	0.84	0.61	0.19	0.26	0.43	0.50	0.52	0.38	0.12	-
DR																										
- Wet season paddy		(l /s/ha)	0.38	1.07	-	0.25	0.99	0.79	0.46	0.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy		(l /s/ha)	-	-	-	-	-	-	-	-	-	0.80	0.23	0.86	1.46	1.38	1.30	0.94	0.17	-	-	-	-	-	-	-
- Palawija		(l /s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	0.40	0.66	0.77	0.80	0.59	0.18	-
Total			0.38	1.07	-	0.25	0.99	0.79	0.46	0.43	-	0.80	0.23	0.86	1.46	1.38	1.30	0.94	0.29	0.40	0.66	0.77	0.80	0.59	0.18	-
Max. Diversion Requirement										=	1.46	lt/sec/ha														

Figure A.3 NFR calculation for Paddy-Paddy-Palawija (Start in January)

Item			Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Des	
			15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16
Basic Data																										
Eto (1)		(mm/day)	3.78	3.68	3.57	3.47	3.38	3.28	3.26	3.25	3.25	3.24	3.23	3.23	3.25	3.39	3.73	4.13	4.58	4.83	4.96	5.03	4.99	4.80	4.41	4.12
Percolation, P (2)		(mm/day)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Reff (3)		(mm/day)	1.96	4.07	3.08	3.75	4.90	2.82	2.39	1.22	0.42	0.25	0.06	0.20	0.09	0.03	-	-	-	-	-	-	-	-	0.32	1.24
Eo = Eto * 1.1 (4)		(mm/day)	4.16	4.05	3.93	3.82	3.72	3.61	3.59	3.58	3.58	3.56	3.56	3.55	3.57	3.73	4.10	4.54	5.03	5.31	5.46	5.53	5.49	5.27	4.85	4.53
M = Eo + P (5)		(mm/day)	7.16	7.05	6.93	6.82	6.72	6.61	6.59	6.58	6.58	6.56	6.56	6.55	6.57	6.73	7.10	7.54	8.03	8.31	8.46	8.53	8.49	8.27	7.85	7.53
T (6)		day	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
S (7)		mm	300.00	300.00	300.00	300.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
K = M * T / S (8)			1.43	1.41	1.39	1.36	2.01	1.98	1.98	1.97	1.97	1.97	1.97	1.97	1.97	2.02	2.13	2.26	2.41	2.49	2.54	2.56	2.55	2.48	2.35	2.26
LP = M * e^k / (e^k -1) (9)		(mm/day)	9.41	9.33	9.24	9.16	7.75	7.66	7.65	7.64	7.64	7.63	7.62	7.62	7.64	7.76	8.06	8.42	8.83	9.06	9.19	9.25	9.21	9.03	8.67	8.41

Cropping Pattern

Item			Jan 15	Jan 16	Feb 14	Feb 14	Mar 15	Mar 16	Apr 15	Apr 15	May 15	May 16	Jun 15	Jun 15	Jul 15	Jul 16	Aug 15	Aug 16	Sep 15	Sep 15	Oct 15	Oct 16	Nov 15	Nov 15	Des 15	Des 16
Crop Coef. Kc :																										
- Wet season paddy (kc)					1.20	1.16	1.06	0.97	0.69	0.23	0.00															
						1.20	1.16	1.06	0.97	0.69	0.23	0.00														
Area factor					0.25	0.50	0.50	0.50	0.50	0.25																
						0.25	0.50	0.50	0.50	0.50	0.25															
Kc with Area Factor (paddy)					0.30	0.88	1.11	1.02	0.83	0.40	0.06	-														
- Dry season paddy (kc)													1.20	1.16	1.06	0.97	0.69	0.23	0.00							
														1.20	1.16	1.06	0.97	0.69	0.23	0.00						
area factor													0.25	0.50	0.50	0.50	0.50	0.25								
														0.25	0.50	0.50	0.50	0.50	0.25							
Kc with Area Factor (paddy)													0.30	0.88	1.11	1.02	0.83	0.40	0.06	-						
Palawija (kc)																			0.70	0.75	0.88	0.91	0.91	0.82	0.41	
																				0.70	0.75	0.88	0.91	0.91	0.82	0.41
Area factor																			0.25	0.50	0.50	0.50	0.50	0.25		
																				0.25	0.50	0.50	0.50	0.50	0.25	
Kc with Area Factor (palawija)																			0.18	0.55	0.82	0.90	0.91	0.66	0.21	-
Land Preparation LP	LP = Σ (RL) . [10]																									
- Wet season paddy			9.41	9.33																						
Area Factor			0.25	0.75																						
LP with Area Factor			2.35	7.00																						
- Dry season paddy (kc)																										
Area Factor											7.64	7.63														
LP with Area Factor											0.25	0.75														
											1.91	5.72														
Consumptive use ETc with Area Factor	ETc = Σ (Kc . RL) . ETo	(mm/day)																								
- Wet season paddy			-	-	1.07	3.06	3.75	3.33	2.71	1.31	0.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy								-	-	-	-	-	0.97	2.84	3.61	3.44	3.10	1.66	0.26	-	-	-	-	-	-	-
- Palawija			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	2.65	4.04	4.50	4.54	3.16	0.90	-
Percolation with Area Factor																										
- Wet season paddy		(mm/day)	-	-	0.75	2.25	3.00	3.00	3.00	2.25	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy		(mm/day)						-	-	-	-	-	0.75	2.25	3.00	3.00	3.00	2.25	0.75	-	-	-	-	-	-	-
- Palawija		(mm/day)																								
Water Layer Replacement	W = 50 / n																									
- Wet season paddy (kc)							3.33		3.33																	
								3.33		3.33																
	Area Factor				0.25	0.50	0.50	0.50	0.50	0.25																
						0.25	0.50	0.50	0.50	0.50	0.25															
	WLR with Area Factor						1.67	1.67	1.67	1.67	-	-														
- Dry season paddy (kc)															3.33		3.33									
																3.33		3.33								
	Area Factor												0.25	0.50	0.50	0.50	0.50	0.25								
														0.25	0.50	0.50	0.50	0.50	0.25							
	WLR with Area Factor														1.67	1.67	1.67	1.67	-	-						
NFR																										
- Wet season paddy	q = LP + ETc + P + W - R_{eff}	(mm/day)	0.39	2.92	-	1.56	3.52	5.18	4.98	4.01	0.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy		(mm/day)	-	-	-	-	-	-	-	-	1.49	5.47	1.66	4.89	8.18	8.08	7.76	5.58	1.01	-	-	-	-	-	-	-
- Palawija		(mm/day)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	2.65	4.04	4.50	4.54	3.16	0.59	-
- Wet season paddy		(l/s/ha)	0.05	0.34	-	0.18	0.41	0.60	0.58	0.46	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy		(l/s/ha)	-	-	-	-	-	-	-	-	0.17	0.63	0.19	0.57	0.95	0.94	0.90	0.65	0.12	-	-	-	-	-	-	-
- Palawija		(l/s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	0.31	0.47	0.52	0.53	0.37	0.07	-
Total		(l/s/ha)	0.05	0.34	-	0.18	0.41	0.60	0.58	0.46	0.23	0.63	0.19	0.57	0.95	0.94	0.90	0.65	0.21	0.31	0.47	0.52	0.53	0.37	0.07	-
DR																										
- Wet season paddy		(l/s/ha)	0.07	0.52	-	0.28	0.63	0.92	0.89	0.71	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Dry season paddy		(l/s/ha)	-	-	-	-	-	-	-	-	0.27	0.97	0.30	0.87	1.46	1.44	1.38	0.99	0.18	-	-	-	-	-	-	-
- Palawija		(l/s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	0.47	0.72	0.80	0.81	0.56	0.10	-
Total			0.07	0.52	-	0.28	0.63	0.92	0.89	0.71	0.36	0.97	0.30	0.87	1.46	1.44	1.38	0.99	0.32	0.47	0.72	0.80	0.81	0.56	0.10	-
		(m^3/s)																								
Max. Diversion Requirement								=	1.46	lt/sec/ha																

Figure A.4 NFR calculation for Paddy-Palawija-Palawija (Start in December)

Item				Des		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
				15	16	15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15
Basic Data	Eto (1)		(mm/day)	4.41	4.12	3.78	3.68	3.57	3.47	3.38	3.28	3.26	3.25	3.25	3.24	3.23	3.23	3.25	3.39	3.73	4.13	4.58	4.83	4.96	5.03	4.99	4.80
	Percolation, P (2)		(mm/day)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
	Reff (3)		(mm/day)	0.32	1.24	1.96	4.07	3.08	3.75	4.90	2.82	2.39	1.22	0.42	0.25	0.06	0.20	0.09	0.03	-	-	-	-	-	-	-	-
	Eo = Eto * 1.1 (4)		(mm/day)	4.85	4.53	4.16	4.05	3.93	3.82	3.72	3.61	3.59	3.58	3.58	3.56	3.56	3.55	3.57	3.73	4.10	4.54	5.03	5.31	5.46	5.53	5.49	5.27
	M = Eo + P (5)		(mm/day)	7.85	7.53	7.16	7.05	6.93	6.82	6.72	6.61	6.59	6.58	6.58	6.56	6.56	6.55	6.57	6.73	7.10	7.54	8.03	8.31	8.46	8.53	8.49	8.27
	T (6)		day	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
	S (7)		mm	300.00	300.00	300.00	300.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
	K = M * T / S (8)			1.57	1.51	1.43	1.41	2.08	2.05	2.01	1.98	1.98	1.97	1.97	1.97	1.97	1.97	1.97	2.02	2.13	2.26	2.41	2.49	2.54	2.56	2.55	2.48
	LP = M * e^k / (e^k -1) (9)		(mm/day)	9.91	9.68	9.41	9.33	7.92	7.83	7.75	7.66	7.65	7.64	7.64	7.63	7.62	7.62	7.64	7.76	8.06	8.42	8.83	9.06	9.19	9.25	9.21	9.03
Cropping Pattern																											
					LP				Paddy			Ripen			Palawija/Jagung				Ripen			Palawija/Jagung				Ripen	
Crop Coef. Kc :																											
	- Wet season paddy (kc)					1.20	1.16	1.06	0.97	0.69	0.23	0.00															
							1.20	1.16	1.06	0.97	0.69	0.23	0.00														
	Area factor					0.25	0.50	0.50	0.50	0.50	0.25																
							0.25	0.50	0.50	0.50	0.50	0.25															
	Kc with Area Factor (paddy)					0.30	0.88	1.11	1.02	0.83	0.40	0.06	-														
	-Palawija 1 (kc)												0.70	0.75	0.88	0.91	0.91	0.82	0.41								
														0.70	0.75	0.88	0.91	0.91	0.82	0.41							
	area factor												0.25	0.50	0.50	0.50	0.50	0.25									
														0.25	0.50	0.50	0.50	0.50	0.25								
	Kc with Area Factor (paddy)												0.18	0.55	0.82	0.90	0.91	0.66	0.21	-							
	Palawija 2 (kc)																			0.70	0.75	0.88	0.91	0.91	0.82	0.41	
																					0.70	0.75	0.88	0.91	0.91	0.82	0.41
	Area factor																			0.25	0.50	0.50	0.50	0.50	0.25		
																					0.25	0.50	0.50	0.50	0.50	0.25	
	Kc with Area Factor (palawija)																			0.18	0.55	0.82	0.90	0.91	0.66	0.21	-
Land Preparation LP		LP = Σ (RL) . [10]																									
	- Wet season paddy			9.91	9.68																						
	Area Factor			0.25	0.75																						
	LP with Area Factor			2.48	7.26																						
	- Dry season paddy (kc)																										
	Area Factor																										
	LP with Area Factor																										
Consumptive use ETc with Area Factor		ETc = Σ (Kc . RL) . ETo	(mm/day)																								
- Wet season paddy				-	-	1.13	3.24	3.97	3.52	2.80	1.32	0.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija											-	-	0.57	1.79	2.64	2.89	2.94	2.14	0.70	-	-	-	-	-	-	-	-
- Palawija				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	2.27	3.73	4.32	4.52	3.32	1.02	-
Percolation with Area Factor																											
- Wet season paddy			(mm/day)			0.75	2.25	3.00	3.00	3.00	2.25	0.75	-														
- Palawija			(mm/day)																								
- Palawija			(mm/day)																								
Water Layer Replacement		W = 50 / n																									
	- Wet season paddy (kc)							3.33		3.33																	
									3.33		3.33																
		Area Factor				0.25	0.50	0.50	0.50	0.50	0.25																
							0.25	0.50	0.50	0.50	0.50	0.25															
		WLR with Area Factor						1.67	1.67	1.67	1.67	-	-	-													
NFR																											
- Wet season paddy		q = LP + ETc + P + W - R_{eff}	(mm/day)	2.16	6.02	-	1.42	5.55	4.44	2.57	2.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija			(mm/day)	-	-	-	-	-	-	-	-	-	-	1.37	2.39	2.84	2.73	2.06	0.67	-	-	-	-	-	-	-	-
- Palawija			(mm/day)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65	2.27	3.73	4.32	4.52	3.32	1.02	-
- Wet season paddy			(l/s/ha)	0.25	0.70	-	0.16	0.64	0.51	0.30	0.28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija			(l/s/ha)	-	-	-	-	-	-	-	-	-	-	0.16	0.28	0.33	0.32	0.24	0.08	-	-	-	-	-	-	-	-
- Palawija			(l/s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.26	0.43	0.50	0.52	0.38	0.12	-
	Total		(l/s/ha)	0.25	0.70	-	0.16	0.64	0.51	0.30	0.28	-	-	0.16	0.28	0.33	0.32	0.24	0.08	0.08	0.26	0.43	0.50	0.52	0.38	0.12	-
DR																											
- Wet season paddy			(l/s/ha)	0.38	1.07	-	0.25	0.99	0.79	0.46	0.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija			(l/s/ha)	-	-	-	-	-	-	-	-	-	-	0.24	0.43	0.51	0.49	0.37	0.12	-	-	-	-	-	-	-	-
- Palawija			(l/s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	0.40	0.66	0.77	0.80	0.59	0.18	-
	Total			0.38	1.07	-	0.25	0.99	0.79	0.46	0.43	-	-	0.24	0.43	0.51	0.49	0.37	0.12	0.12	0.40	0.66	0.77	0.80	0.59	0.18	-
Max. Diversion Requirement											=	1.07	lt/sec/ha														

Figure A.5 NFR calculation for Paddy-Palawija-Palawija (Start in January)

I t e m			Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Des	
			15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16
Basic Data																										
Eto (1)		(mm/day)	3.78	3.68	3.57	3.47	3.38	3.28	3.26	3.25	3.25	3.24	3.23	3.23	3.25	3.39	3.73	4.13	4.58	4.83	4.96	5.03	4.99	4.80	4.41	4.12
Percolation, P (2)		(mm/day)	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Reff (3)		(mm/day)	1.96	4.07	3.08	3.75	4.90	2.82	2.39	1.22	0.42	0.25	0.06	0.20	0.09	0.03	-	-	-	-	-	-	-	-	0.32	1.24
Eo = Eto * 1.1 (4)		(mm/day)	4.16	4.05	3.93	3.82	3.72	3.61	3.59	3.58	3.58	3.56	3.56	3.55	3.57	3.73	4.10	4.54	5.03	5.31	5.46	5.53	5.49	5.27	4.85	4.53
M = Eo + P (5)		(mm/day)	7.16	7.05	6.93	6.82	6.72	6.61	6.59	6.58	6.58	6.56	6.56	6.55	6.57	6.73	7.10	7.54	8.03	8.31	8.46	8.53	8.49	8.27	7.85	7.53
T (6)		day	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
S (7)		mm	300.00	300.00	300.00	300.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00	200.00
K = M * T / S (8)			1.43	1.41	1.39	1.36	2.01	1.98	1.98	1.97	1.97	1.97	1.97	1.97	1.97	2.02	2.13	2.26	2.41	2.49	2.54	2.56	2.55	2.48	2.35	2.26
$LP = M * e^k / (e^k -1)$ (9)		(mm/day)	9.41	9.33	9.24	9.16	7.75	7.66	7.65	7.64	7.64	7.63	7.62	7.62	7.64	7.76	8.06	8.42	8.83	9.06	9.19	9.25	9.21	9.03	8.67	8.41
Cropping Pattern																										
							Paddy			Ripen				Palawija/Jagung				Ripen			Palawija/Jagung				Ripen	
Crop Coef. Kc :																										
- Wet season paddy (kc)					1.20	1.16	1.06	0.97	0.69	0.23	0.00															
						1.20	1.16	1.06	0.97	0.69	0.23	0.00														
Area factor					0.25	0.50	0.50	0.50	0.50	0.25																
						0.25	0.50	0.50	0.50	0.50	0.25															
Kc with Area Factor (paddy)					0.30	0.88	1.11	1.02	0.83	0.40	0.06	-														
- Dry season paddy (kc)												0.70	0.75	0.88	0.91	0.91	0.82	0.41								
													0.70	0.75	0.88	0.91	0.91	0.82	0.41							
area factor												0.25	0.50	0.50	0.50	0.50	0.25									
													0.25	0.50	0.50	0.50	0.50	0.25								
Kc with Area Factor (palawija)												0.18	0.55	0.82	0.90	0.91	0.66	0.21	-							
Palawija (kc)																			0.70	0.75	0.88	0.91	0.91	0.82	0.41	
																				0.70	0.75	0.88	0.91	0.91	0.82	0.41
Area factor																			0.25	0.50	0.50	0.50	0.50	0.25		
																				0.25	0.50	0.50	0.50	0.50	0.25	
Kc with Area Factor (palawija)																			0.18	0.55	0.82	0.90	0.91	0.66	0.21	-
Land Preparation LP	LP = Σ (RL) . [10]																									
- Wet season paddy			9.41	9.33																						
Area Factor			0.25	0.75																						
LP with Area Factor			2.35	7.00																						
Consumptive use ETc with Area Factor	ETc = Σ (Kc . RL) . ETo	(mm/day)																								
- Wet season paddy			-	-	1.07	3.06	3.75	3.33	2.71	1.31	0.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija								-	-	-	-	0.57	1.78	2.63	2.91	3.09	2.46	0.85	-	-	-	-	-	-	-	-
- Palawija			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	2.65	4.04	4.50	4.54	3.16	0.90	-
Percolation with Area Factor																										
- Wet season paddy		(mm/day)	-	-	0.75	2.25	3.00	3.00	3.00	2.25	0.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija		(mm/day)																								
- Palawija		(mm/day)																								
Water Layer Replacement	W = 50 / n																									
- Wet season paddy (kc)							3.33		3.33																	
								3.33		3.33																
	Area Factor				0.25	0.50	0.50	0.50	0.50	0.25																
						0.25	0.50	0.50	0.50	0.50	0.25															
	WLR with Area Factor						1.67	1.67	1.67	1.67	-	-														
NFR																										
- Wet season paddy	$q = LP + ETc + P + W - R_{eff}$	(mm/day)	0.39	2.92	-	1.56	3.52	5.18	4.98	4.01	0.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija		(mm/day)	-	-	-	-	-	-	-	-	-	0.32	1.72	2.43	2.82	3.06	2.46	0.85	-	-	-	-	-	-	-	-
- Palawija		(mm/day)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	2.65	4.04	4.50	4.54	3.16	0.59	-
- Wet season paddy		(l/s/ha)	0.05	0.34	-	0.18	0.41	0.60	0.58	0.46	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija		(l/s/ha)	-	-	-	-	-	-	-	-	-	0.04	0.20	0.28	0.33	0.35	0.28	0.10	-	-	-	-	-	-	-	-
- Palawija		(l/s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09	0.31	0.47	0.52	0.53	0.37	0.07	-
Total		(l/s/ha)	0.05	0.34	-	0.18	0.41	0.60	0.58	0.46	0.06	0.04	0.20	0.28	0.33	0.35	0.28	0.10	0.09	0.31	0.47	0.52	0.53	0.37	0.07	-
DR																										
- Wet season paddy		(l/s/ha)	0.07	0.52	-	0.28	0.63	0.92	0.89	0.71	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Palawija		(l/s/ha)	-	-	-	-	-	-	-	-	-	0.06	0.31	0.43	0.50	0.54	0.44	0.15	-	-	-	-	-	-	-	-
- Palawija		(l/s/ha)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	0.47	0.72	0.80	0.81	0.56	0.10	-
Total			0.07	0.52	-	0.28	0.63	0.92	0.89	0.71	0.09	0.06	0.31	0.43	0.50	0.54	0.44	0.15	0.14	0.47	0.72	0.80	0.81	0.56	0.10	-
Max. Diversion Requirement								=	0.92	lt/sec/ha																

A.7 Proposed location of hydrological monitoring within the study area

Maro watershed

The existing climatology station in Maro watershed is located at Mopah and Tanah Miring Climatology station, these stations are sufficiently representative to describe the climatic conditions in the watershed. See Appendix A for photos of the Tanah Miring Climate Station; it was built in 2019 and the equipment for climate monitoring are quite good except the evaporation gauge. Both climatological stations are located at downstream of the watershed, therefore it is purposed one more climatological station located in the upstream of the watershed, precisely in Jagebob 13, considering the possibility of climate differences between downstream and upstream. In addition to climatology tools, to support agricultural conditions, it is recommended that tools such as: soil pH meter and clinometer are included for the purpose of ground truthing monitoring.

Between Mopah and Tanah Miring Climate Stations, Mopah is the chosen one and considered representative for the climatic and hydrological conditions in the watershed. The availability of daily rainfall data of Mopah started from 1952 to 1983, and extended from 1990 to 2019. If it is compared to the Tanah Miring data whose has monthly rainfall only during 2015 to 2020, Mopah is the better due to the minimum requirement data of rainfall being 10 years. Based on this, Mopah is reasonable to be selected. Likewise, with the rainfall, the climate data from Mopah is more extensive (2005-2019) and was used for further hydrological analyses.

The maximum proposed number of rain posts based on the Kagan Rodda method, about 15 locations, some of which would ideally be in Papua New Guinea. However, this number is reduced to 5 locations based on the existing access roads and the dispersion of the existing rain posts, see **Table A.3** and **Figure A.6**. The accumulative posts with the existing ones are total 18 units, see **Table A.3**. According to the WMO standard, the number of rain posts should be between 9-81 spots, thus the 18 proposed locations comply with the requirement.

Also, in **Figure A.6** indicates there are four AWLR that are installed in the upstream where they are not affected by tidal influence (which is assumed to extend for 98 km towards to the upstream of Maro). There is only one AWLR installed in the downstream area, which may be affected by the tides. Based on the number of existing AWLR on site, there is no need to instal new ones, just need to maintain the existing ones and tidy up the data log.

Table A.3 Coordinates of the proposed rainfall stations in the Maro watershed

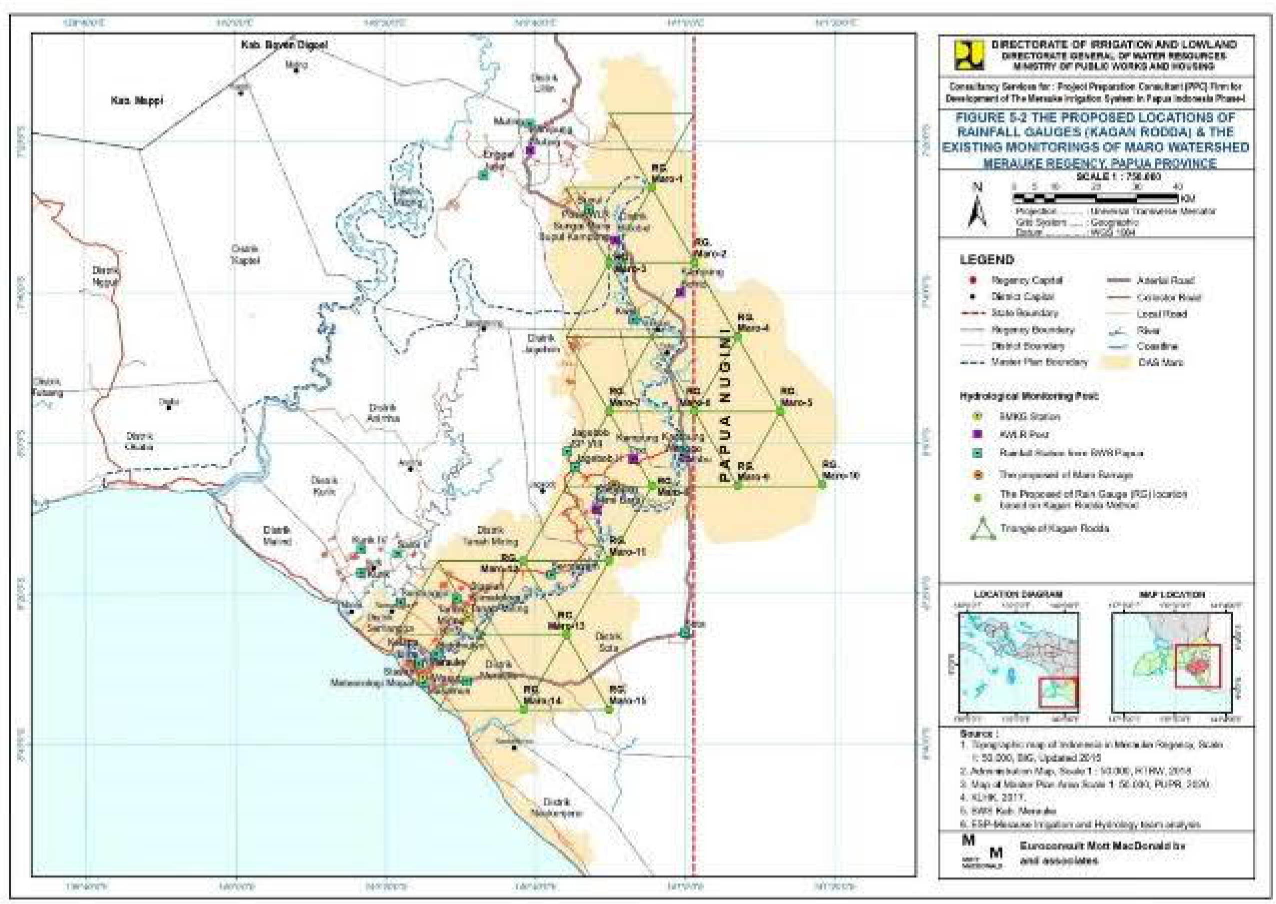
No	ID of The Proposed Rainfall Gauge	Coordinates		The main Proposed of RG
		X	Y	
1	RG. Maro-1	140.92771	-7.43353	
2	RG. Maro-2	141.01717	-7.60104	Out of the border
3	RG. Maro-3	140.82872	-7.60295	The Main Proposed-1
4	RG. Maro-4	141.11806	-7.76285	Out of the border
5	RG. Maro-5	141.21134	-7.92846	Out of the border
6	RG. Maro-6	141.01717	-7.92846	Out of the border
7	RG. Maro-7	140.82872	-7.93036	The Main Proposed-2
8	RG. Maro-8	140.92580	-8.09407	The Main Proposed-3
9	RG. Maro-9	141.11235	-8.09597	Out of the border
10	RG. Maro-10	141.30081	-8.09407	Out of the border
11	RG. Maro-11	140.83062	-8.26158	
12	RG. Maro-12	140.64027	-8.25778	
13	RG. Maro-13	140.73735	-8.42910	The Main Proposed-4
14	RG. Maro-14	140.63836	-8.59090	

15	RG. Maro-15	140.83253	-8.59280	The Main Proposed-5

Source: The result of analysis

Note: The green colour showing the prioritized number of the rainfall gauge

Figure A.6 Recommended locations for monitoring network in Maro watershed



Kumbe watershed

Kumbe watershed covers 4,711 km^2 and is smaller than the Maro. The total rainfall stations are 5 with the spread of them being quite dense in the downstream area rather than in the area upstream of the proposed weir. This circumstance is similar with Maro. Rainfall Station of Kurik, Kurik IV and Salor II are situated in the downstream, meanwhile Jagebob SP VII and Muting are in the upstream. There is only one AWLR post located on Kumbe Hulu River which is near to the Muting rain post.

Kagan Rodda's analysis resulted the number of rain posts is 17 with the estimated length of the triangles is about 18 km. Taking note of the existing access roads and also the rainfall stations, the number of the rainfall posts can be optimized into 5, see **Table A.4**, and then **Figure A.6** which shows the coordinates for each rain gauge and the prioritized ones. Meanwhile, WMO states that the range number is 5–47 referring to the catchment area of this watershed. Therefore, the total of the proposed and the existing ones is 10 and meets the WMO standard.

There is no climatology station in the Kumbe watershed, therefore a climatology station located in Kurik is recommended with several climate monitoring tools such as: temperature meter, wind speed meter, evapotranspiration meter and sunlight temperature meter. In addition to these climatological tools, several tools are also recommended, such as: soil PH meter, clinometer as the purpose of ground truthing monitoring.

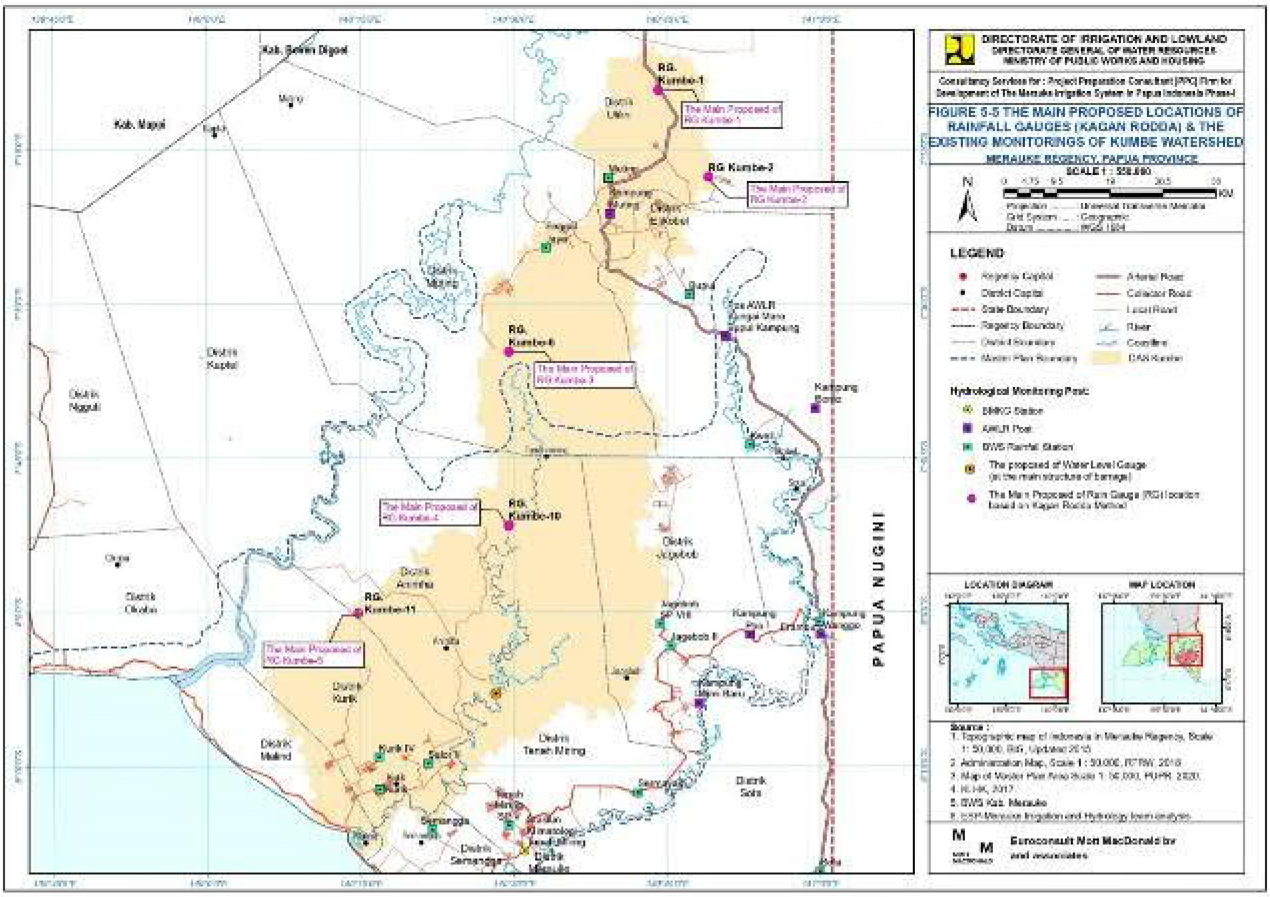
Table A.4 Coordinates of the proposed rainfall stations in the Kumbe watershed

No.	ID of The Proposed Rainfall Gauge	Coordinates		The main Proposed of RG
		X	Y	
1	RG. Kumbe-1	140.73735	-7.15742	The Main Proposed-1
2	RG. Kumbe-2	140.81433	-7.29819	The Main Proposed-2
3	RG. Kumbe-3	140.73545	-7.43915	
4	RG. Kumbe-4	140.57126	-7.43486	
5	RG. Kumbe-5	140.65264	-7.57478	
6	RG. Kumbe-6	140.49131	-7.57620	The Main Proposed-3
7	RG. Kumbe-7	140.57126	-7.72040	
8	RG. Kumbe-8	140.73545	-7.71897	
9	RG. Kumbe-9	140.65407	-7.86031	
10	RG. Kumbe-10	140.49131	-7.85746	The Main Propoped-4
11	RG. Kumbe-11	140.24575	-8.00165	The Main Proposed-5
12	RG. Kumbe-12	140.40851	-7.99879	
13	RG. Kumbe-13	140.56984	-8.00022	
14	RG. Kumbe-14	140.73973	-7.99879	
15	RG. Kumbe-15	140.65621	-8.14156	
16	RG. Kumbe-16	140.32784	-8.14156	
17	RG. Kumbe-17	140.16509	-8.14013	

Source: The result of analysis

Note: The green colour shows the prioritized number of the rainfall gauge

Figure A.7 Recommended locations for monitoring network in Kumbe watershed



Appendix C. Flood Protector Design

Firstly, the Kumbe and Maro cross sections (generated from DEMNAS DEM were originally input into the model. A visual view of the river long section showing bed and bank elevations from the cross sections is shown on Figure B.1 and Figure B.2.

Figure B.1 Long Section of Kumbe River

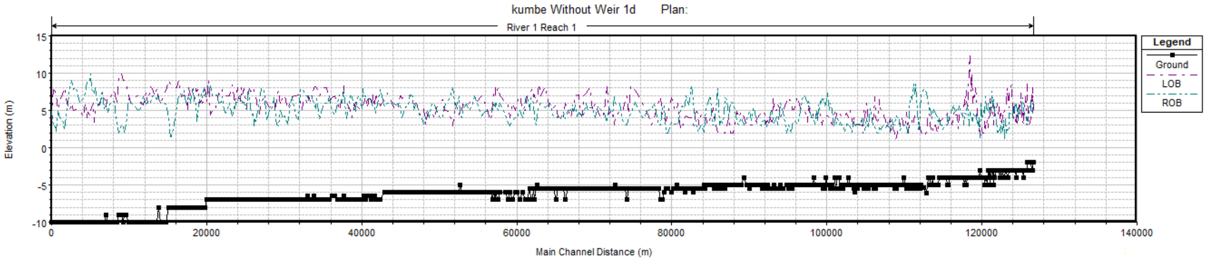
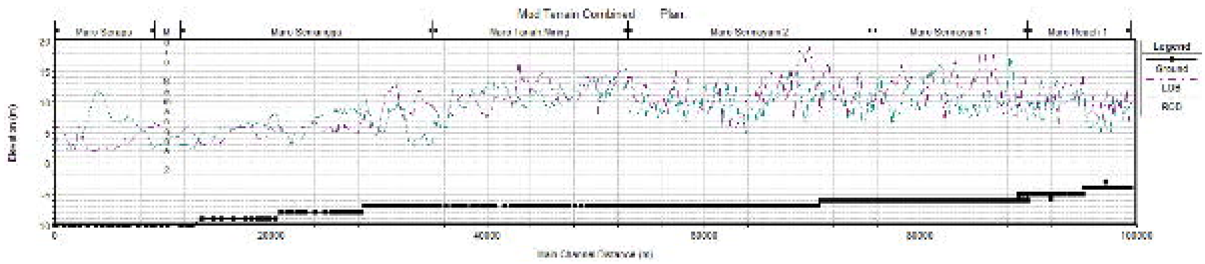
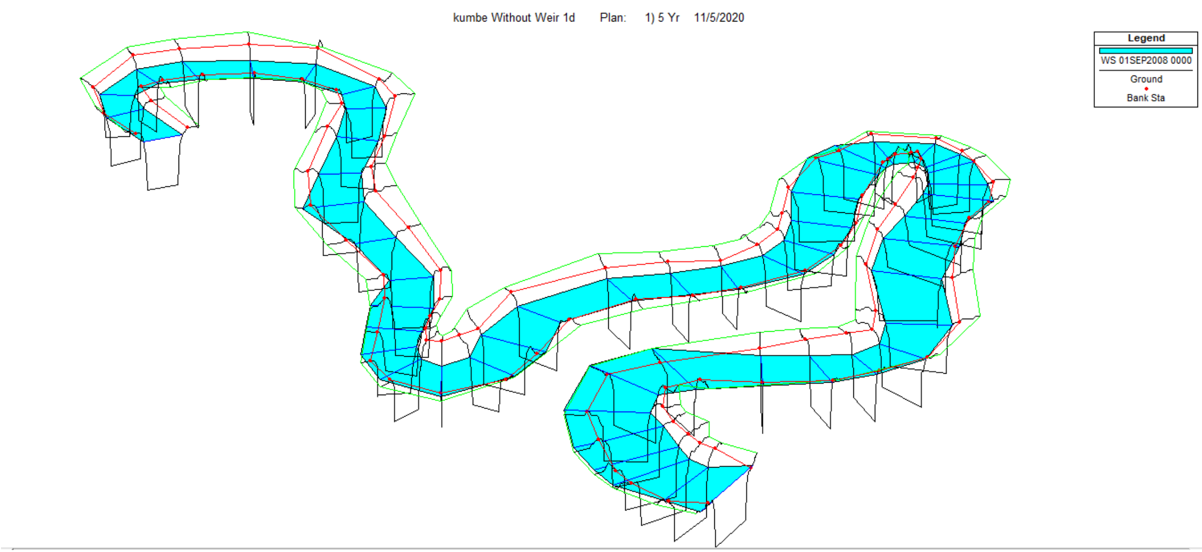


Figure B.2 Long Section of Maro River



A schematic diagram showing how the cross sections make up a part of the Kumbe River profile is shown in Figure B.3.

Figure B.3 3d View of some part from Kumbe river



The Flow data for a (5-year return period flood discharge is entered into the model in the form of a hydrograph as shown in Figure B.4 and Figure B.5 forms the upstream boundary conditions). Tidal data forms the downstream boundary condition as represented by the time series of sea levels in Figure B.6.

Figure B.4 Flow data for Kumbe Upstream Boundary Condition (25 year return period)

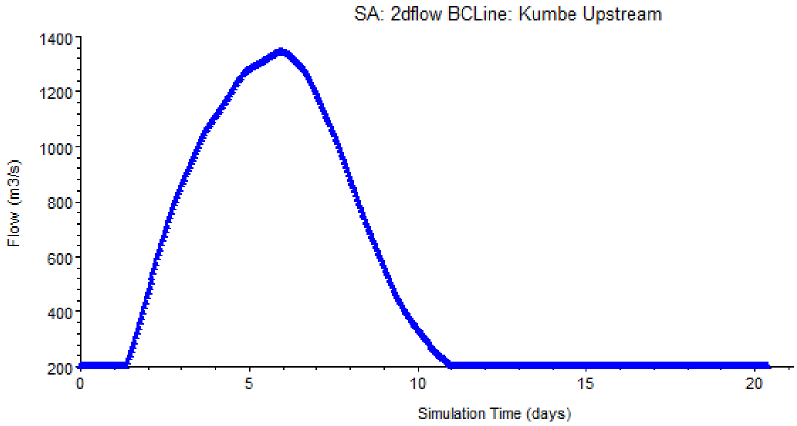
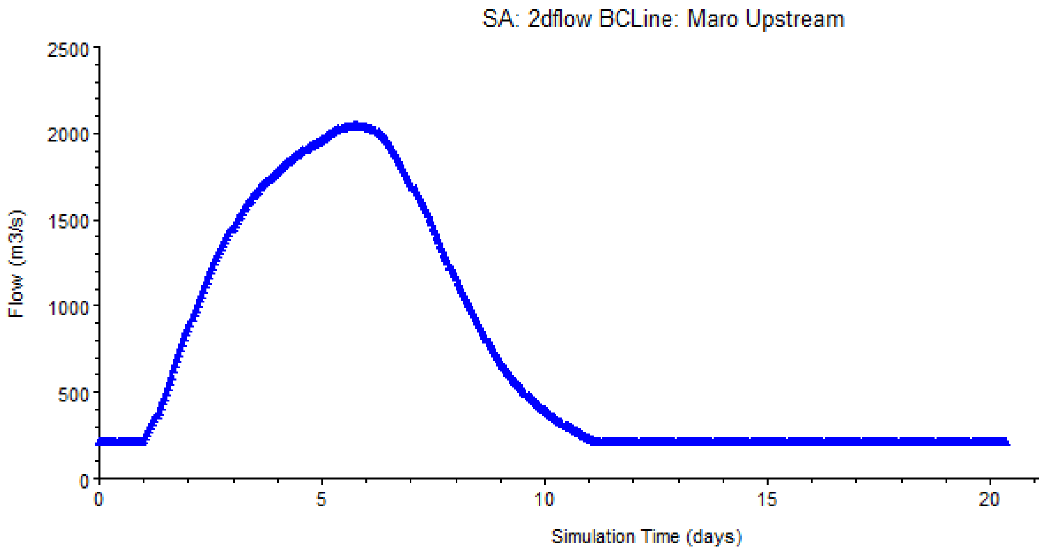
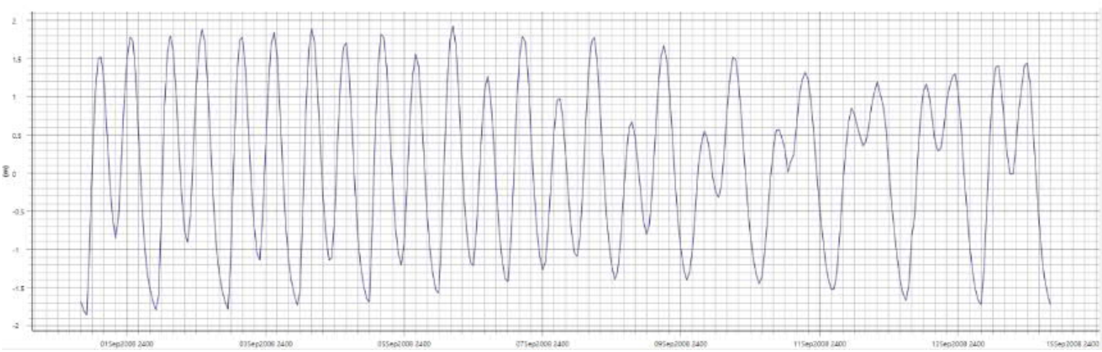


Figure B.5 Flow data for Maro Upstream Boundary Condition (25 year return period)



The Tides data is shown below. The data obtained from Balai Teknik Rawa survey from August 2016 on Maro downstream.

Figure B.6 Tides Data for Downstream Boundary Condition



Source: Balai Teknik Rawa Data

The model is based on the parameters shown in Figure B.7.

Figure B.7 Model parameter

	Parameter	(Default)	2df
1	Theta (0.6-1.0)	1	1
2	Theta Warmup (0.6-1.0)	1	1
3	Water Surface Tolerance [max=0.06](m)	0.003	0.003
4	Volume Tolerance (m)	0.003	0.003
5	Maximum Iterations	20	20
6	Equation Set	SWE-ELM (original/faster)	SWE-ELM (original/faster)
7	Initial Conditions Time (hrs)		
8	Initial Conditions Ramp Up Fraction (0-1)	0.1	0.1
9	Number of Time Slices (Integer Value)	1	1
10	Turbulence Model	Non-Conservative (original)	Non-Conservative (original)
11	Longitudinal Mixing Coefficient		
12	Transverse Mixing Coefficient		
13	Smagorinsky Coefficient	0	0
14	Boundary Condition Volume Check	☐	☐
15	Latitude for Coriolis (-90 to 90)		
16	Solver Cores	All Available	All Available
17	Matrix Solver	PARDISO (Direct)	PARDISO (Direct)
18	Convergence Tolerance		
19	Minimum Iterations	0	0
20	Maximum Iterations	0	0
21	Restart Iteration	10	10
22	Relaxation Factor	1.3	1.3
23	SOR Preconditioner Iterations	10	10

Figure B.8 2D Flow Area of the Model

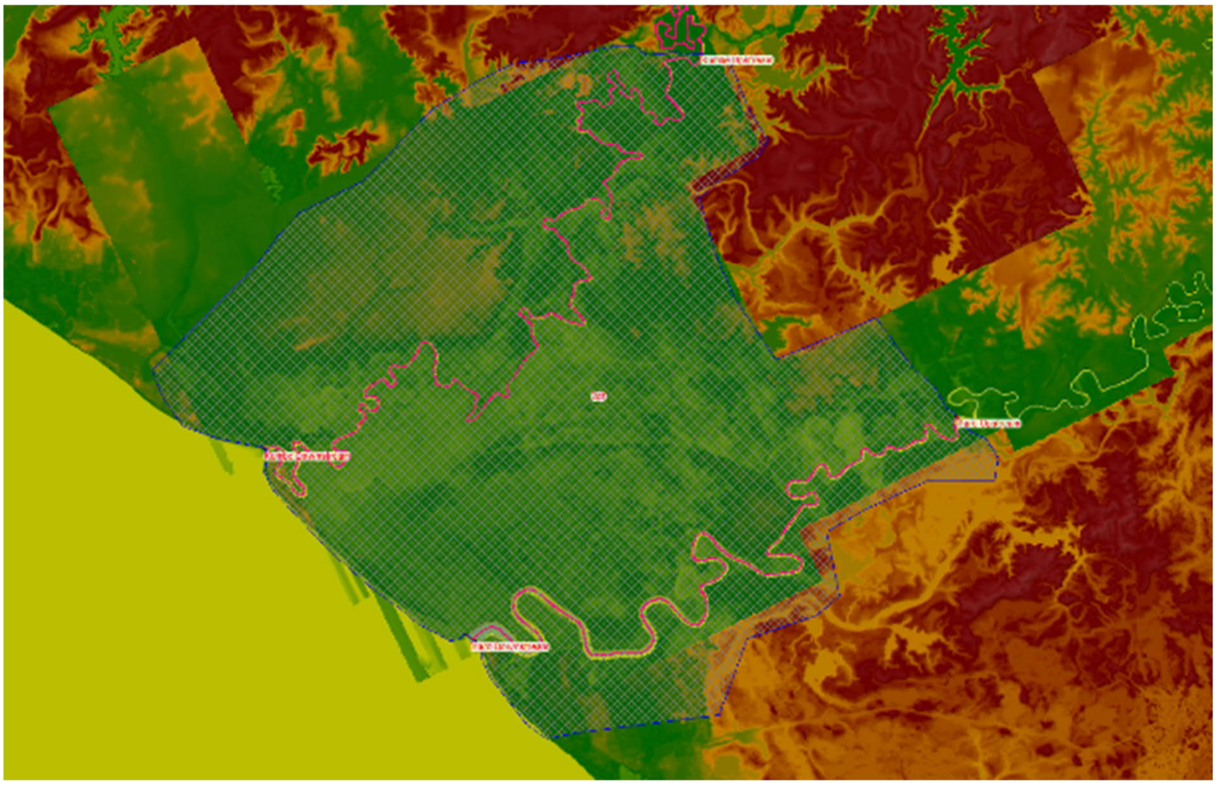
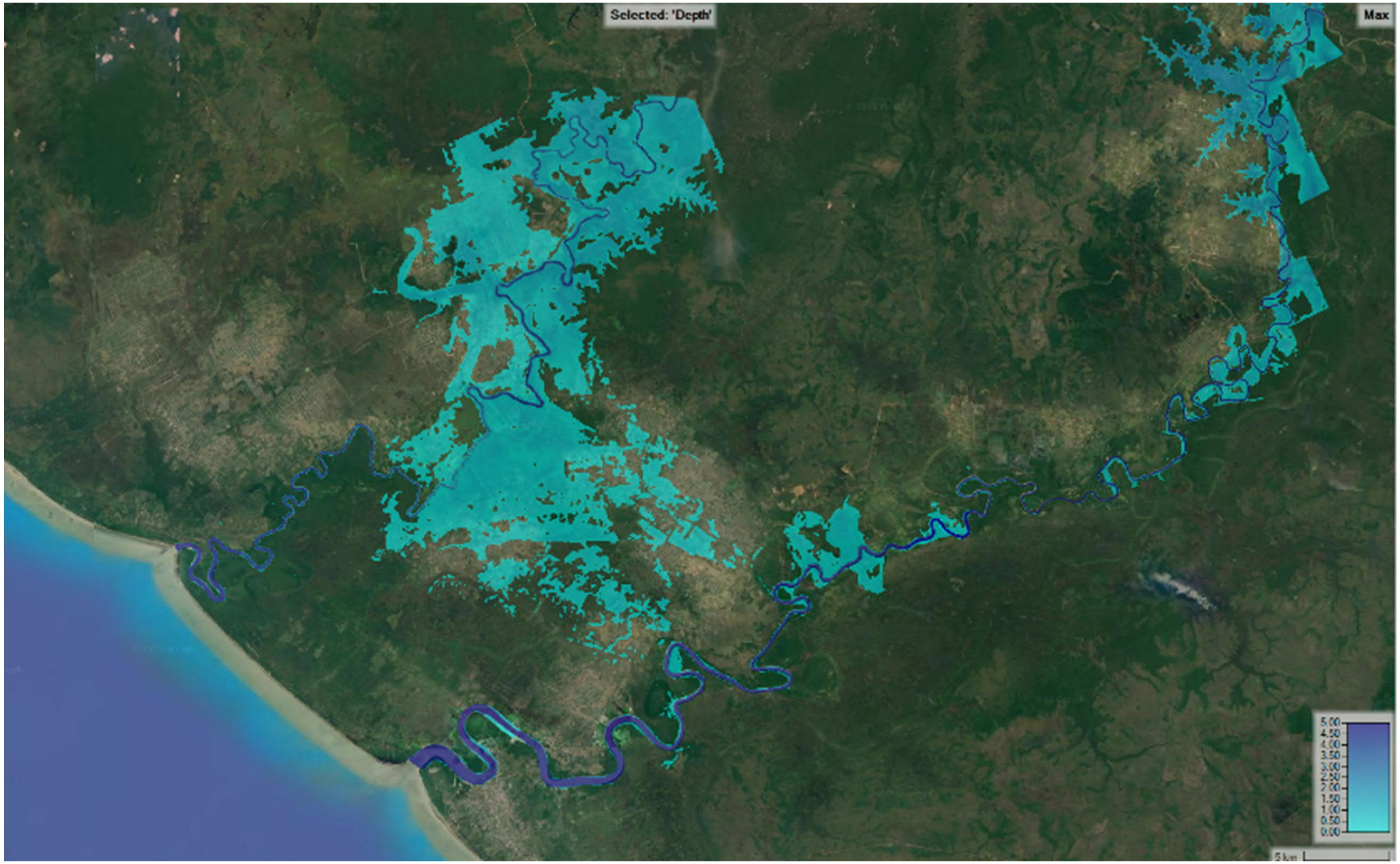


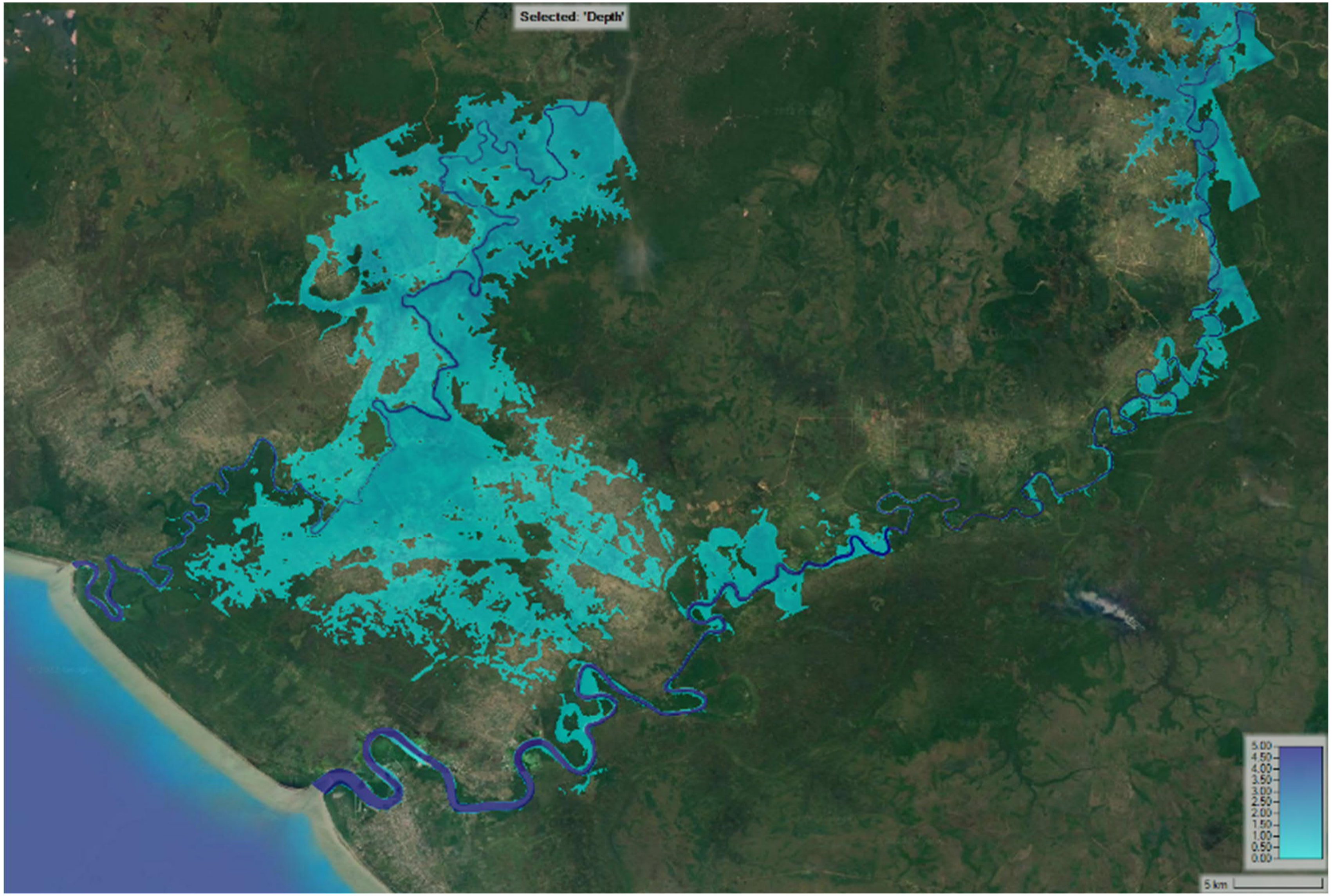
Figure B.8 above shows the area of the simulation for the flood model. The cell of 2D Flow area is set to 40m x 40m (with 10m of break lines) to simulate.

Figure B.9 Result of the 2-D Model for 5 year return period simulation



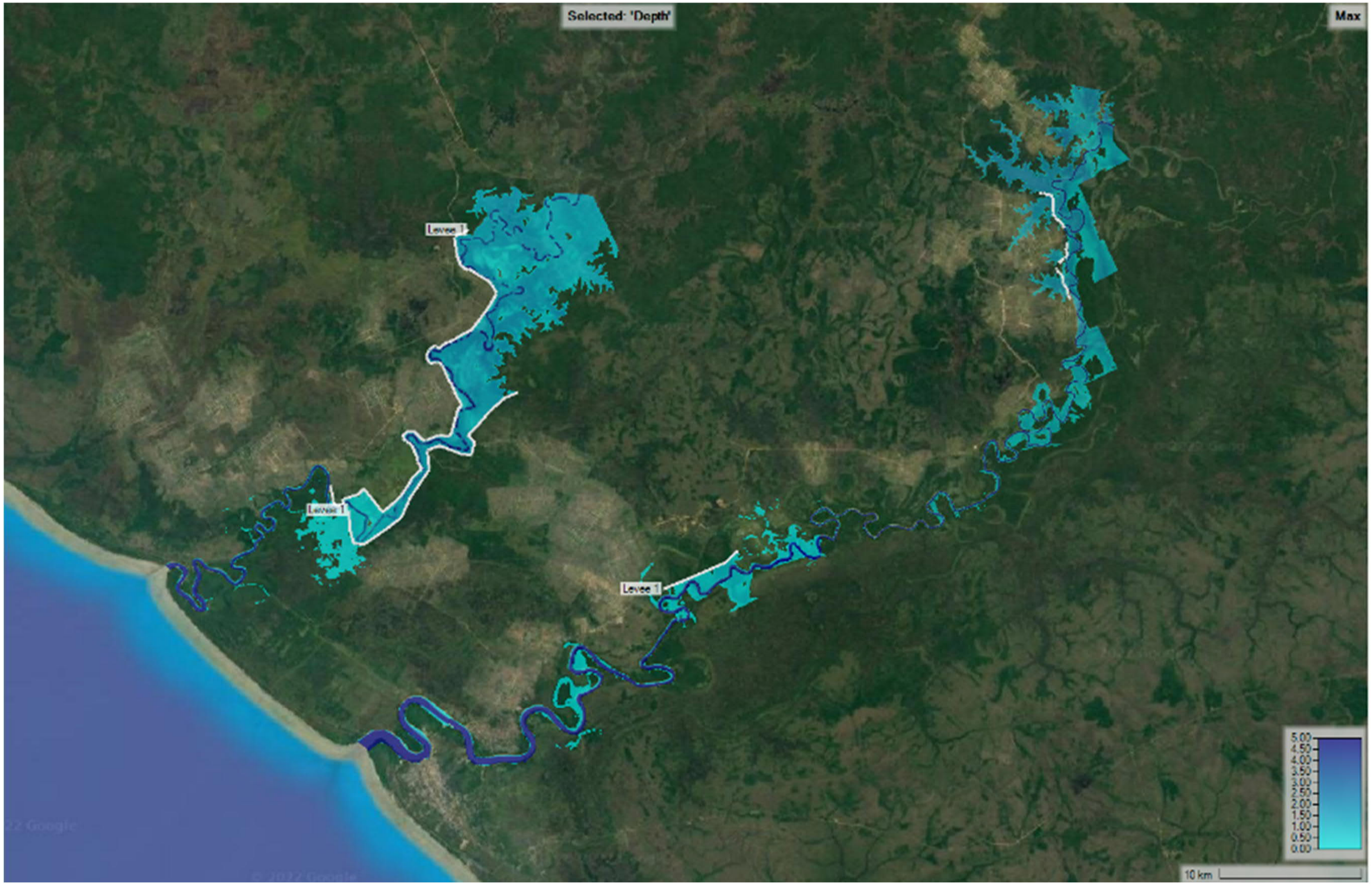
From the result we can see that Kurik and Salor irrigation area is flooded because water surface elevation is shown above the riverbanks of Kumbe. And for Maro, the flood area only affected Jagebob district area.

Figure B.10 Result of 2d model for 25 year return period simulation



For the 25-year return period the inundation area seems more larger, especially on the Tanah miring scheme that also submerged.

Figure B.11 Result of 2d model using dikes



Appendix D. Layout Plan and Schematic Diagram

The layout plan and schematic diagram for each scheme can be seen in the **Lowland Irrigation Report Volume 2**.

Appendix E. Design drawings

The canal drawing for each scheme can be seen in in the **Quantities and Tender Document** reports.

Appendix F. Bill of quantities

The Bill of Quantities can be seen in the **Quantities and Tender Document** reports.

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