Republic of Vanuatu
Department of Energy, Ministry of Climate Change

PREPARATORY SURVEY
FOR
THE PROJECT FOR THE CONSTRUCTION
OF
HYDROPOWER STATION
IN
ESPIRITU SANTO ISLAND

FINAL REPORT

February 2021

Japan International Cooperation Agency

NEWJEC Inc.
CTI Engineering International Co,. Ltd.

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PREFACE

Japan International cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to the Consortium of NEWJEC Inc. and CTI Engineering International Co., LTD.

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

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

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

February 2021

Kiyoshi AMADA
Director General
Infrastructure Management Department
Japan International Cooperation Agency

SUMMARY

1. Summary of Vanuatu

The Republic of Vanuatu (hereinafter referred to "Vanuatu") is located in the western part in the Western Pacific Ocean and consists of about 80 island stretching over 1,200 km from north and south. Population of Vanuatu is approximately 29.3 million and a total area is 12, 189 km^2 (World bank, 2018). Around 33% population of the total population of Vanuatu is concentrated in Efate Island, where the capital city, Port Vila is located. The Espritu Santo Island (hereinafter referred to "Santo") is the largest island in Vanuatu, where the second largest city, Luganville is located. Santo Island accounts for around 18% population of the total population of Vanuatu.

The objective site is located in the southern part of Santo Island, around latitude 15 degree south. The region has a tropical rainforest climate and the seasons are clearly divided into rainy season from May to October and dry season from November to April. In the wet season the climate is a little hot and in the dry season the climate is a little cold. However, the difference of temperature between the wet season and dry season is small. The annual temperature variation is between 21 to 31℃.

A cyclone named PAM caused a great deal of damage throughout the country in 2015. These natural disasters have a huge negative impact on the economic growth. After that, service sector of public infrastructure project encourages the economy, as a result the plus growth was achieved in 2016 and 2017.

GDP in 2018 is 9.14 hundred million USD in total and 3,130 USD per person. Economic growth rate is around 3.2% and inflation rate of commodity price is 2.9 %. Main industries are agriculture and tourism. Production of copra and self-sufficiency agriculture are basis of their life and there is a big gap between urban and rural areas. In recent year, agriculture diversification and tourism promotion are emphasized.

2. Background and Outline of the Project

The Sarakata River hydroelectric power plant (300kW × 2 units in 1994 to 1995, 600kW × 1 unit in 2009 total 1,200kW) constructed as the Japanese Grant project had been contributing to stable power supply as a main power source in Luganville power system, Santo Island. However, the existing Sarakata River hydroelectric power plant alone could not cover the electricity demand in Santo Island, where daytime peak load reached 1,932kW in 2016. Therefore, power supply in Santo Island had been covered with the diesel power plants which depend on expensive import fuel. The electricity demand has been growing in Santo Island and the future power demand is forecasted to increase surely. So, assuming the present power source mix the dependence on the diesel power plants is anticipated to be expanded.

The Government of Vanuatu (hereinafter referred to as "GOV") formulated National Sustainable Development Plan 2016 to 2030, which defined that the development shall be achieved with balance of three pillars of Society, Environment and Economy. In the Energy Sector, Updated Vanuatu Nation Energy Road Map 2016-2030 (hereinafter referred to as "Updated NERM") was issued in 2016. The overall vision of Updated NERM is to energize Vanuatu's growth and development through the provision of secure, affordable, widely accessible, high quality, and clean energy services. The following two projects in Espiritu Santo Island (hereinafter referred to as "Santo Island") are listed as the highest priority actions in Updated NERM 2016-2030.

- Grid Extension, East Coast Santo
- Sarakata Hydro Power Extension Project (600kW)

JICA launched the strategy called “Island Hybrid Initiative” in the pacific island regions. The Japanese Government announced that improvement of rate of renewable energy is cognized as importance of this project, which will be implemented as a part of supporting the achievement of low-carbon development through continuous implementation, in line with this “Hybrid Island Concept” in the 8th Pacific Ocean Island Summit leaders’ declaration in 2015.

Based on these situations, further introduction of renewable energy will reduce the dependence and consumption of imported fuel and will lower electric bill and reduce the effects of global warming. The new hydroelectric power project is very important in order to achieve the above effects.

3. Summary of Survey Results and Outline of the Project (Outline Design, Facility Plan and Equipment Plan)

JICA dispatched the survey team to Vanuatu from November 2018 and October 2019 as follows.

First site survey:	from November 11th 2018 to December 9th, 2018
Second site survey: (Geological investigation)	from February 14th 2019 to March 3rd, 2019 and from March 30th to April 10th, 2019
Third site survey: (Environmental and Social investigation)	from February 11th 2019 to March 31st, 2019 and from September 25th to October 5th, 2019

During the first site survey JICA survey team carried out a site reconnaissance, river longitudinal survey and discharge measurement and verified the planned locations of the intake weir, open channel route, power plant determined by Data collection survey. Based on the results of site investigations, alternative plans were examined. Regarding the existing 20 kV transmission line comparative study of alternatives for the connecting a new hydropower plant and route selection survey were conducted. Because access roads to the intake weir and powerhouse sites are very long (about 6.2 km) and reach to steep valley, the construction work is large-scale and difficult. In this reason, Vanuatu side requested JICA survey team to be burden by the finance of Japanese Government.

During the second site survey progress and results of topographic survey and geological investigations as natural condition investigations were checked and instructions to sub-contractors were conducted. Regarding environmental social investigations, land owners were identified in order to get acquisition of project site and discussion on process of land acquisition with Vanuatu side. Discussions on EIA and SIA were conducted with the sub-contractor and relevant agencies.

Based on the results of a site reconnaissance, topographic survey and geological investigations, basic design of civil facilities and architectural facilities, procurement plan of electro-mechanical equipment for the hydropower plant, SCADA, substation equipment and equipment and materials for the transmission line facilities, construction plan, preliminary construction cost estimates and so on were conducted in Japan. Because the site survey could not be conducted due to COVID-19, contents of outline design, responsibilities of Vanuatu side etc. were explained to, discussed and confirmed with Vanuatu side and agreed with Japan side and Vanuatu side on October 8th, 2020 via Web conference.

Overall plan of the Project is as follows:

Power Generation Type		Run-of-River type	
Installed Capacity	Total	kW	1,000
	Single	kW	500
Plant Discharge	Total	m^3/s	4.2
	Single	m^3/s	2.1
Head	Gross Head	m	33.0
	Effective Head	m	32.3
Number of Turbine & Generator		unit	2
Annual Power Generation		MWh/year	9,020

Regarding related services of GCF, JICA dispatched a survey team to Vanuatu in order to conduct discussions on site with related agencies of Vanuatu and data/ information collection from October 27th to November 4th, 2020. Lead office of GCF National Designated Authority (NDA) of Vanuatu is DOE. The survey team discussed on the proposed scheme with Director General of DOE. DOE gave the survey team comments that DOE wants to determine which scenario is proposed based on discussions with related agencies of Vanuatu and JICA as GCF Accredited Entity (AE). It was confirmed to proceed the application of GCF with DOE in charge of this Project.

4. Project Implementation Schedule and Project Cost Estimate

1) Construction Period

The period of detailed design and bidding preparation (including bidding period) is 8 months and one of facilities construction and equipment procurement is 43.1 months. So, Total project period is 51.1 months.

2) Initial Cost Estimation

Cost borne by the Vanuatu side

The cost borne by Vanuatu side: VUV 71,476,000.

Contents	Price in VUV
Site acquisition/ Compensation for land users and owners/ land rent for disposal area if necessary	60,375,000
Repairs and maintenance expenses for existing access roads	2,247,000
Preparation and provision of lands for stockyard and parking place	105,000
Preparation and provision of lands for site offices	105,000
Commission related to Banking Arrangement (B/A) and Authorization to Pay (A/P)	3,786,000
Customs clearance of the products at ports of disembarkation in Vanuatu	3,500,000
Approval of EIA (Conditions of approval should be fulfilled, if any) and securement of the necessary budget for implementation	100,000
Obtaining the planning, zoning, building, and water works permit	50,000
Preparation and provision of lands for temporary disposal area for surplus soil	1,208,000
Total	71,476,000

Cost borne by the Japan Grant Aid

This is closed due to the confidentiality.

5. Project Evaluation

1) Relevance

The relevance of the Project is judged to be high as described below:

- This Project will contribute to improve the renewable energy ratio based on the energy roadmap of Vanuatu
- Reduce dependence on imported fuels and reduce electricity tariff
- Contribute to climate change countermeasures by reducing dependence on imported fuel
- The effect of reducing the imported fuel by this project can be utilized as a source for the National Green Energy Fund to support rural electrification projects
- This project will be implemented as a part of supporting the achievement of low-carbon development through continuous implementation, in line with this "Hybrid Island Concept".

2) Effectiveness

Quantitative Effect

The quantitative effects expected from this Project are reduction of imported fuel costs by reducing fuel for diesel power generation, increasing of renewable energy ratio, and mitigation of climate change by reducing greenhouse gasses.

The target year is 2028, three (3) years after the commencement of commercial operation.

Quantitative Effects

Index name	Standard value	Target Value (2028) [3 years after the commercial operation of the Project]
Sales Electric Energy (MWh/year)	0	6,692 MWh /year
Reduction of greenhouse gasses (ton/year)	0	602,280 ton/year
Fuel reduction amount for diesel power generation	0	1,940 kliter/year

Qualitative effect

The qualitative effects are as follows;

- Promoting the use of renewable energy, which contributes to improved economic/social development and reduction of greenhouse gas emissions
- Diversification of electric power supply sources
- Achievement of a stable energy supply
- Expansion of power supply area and improvement of public services
- Improvement of public security and promotion of community activities because of increasing street lights

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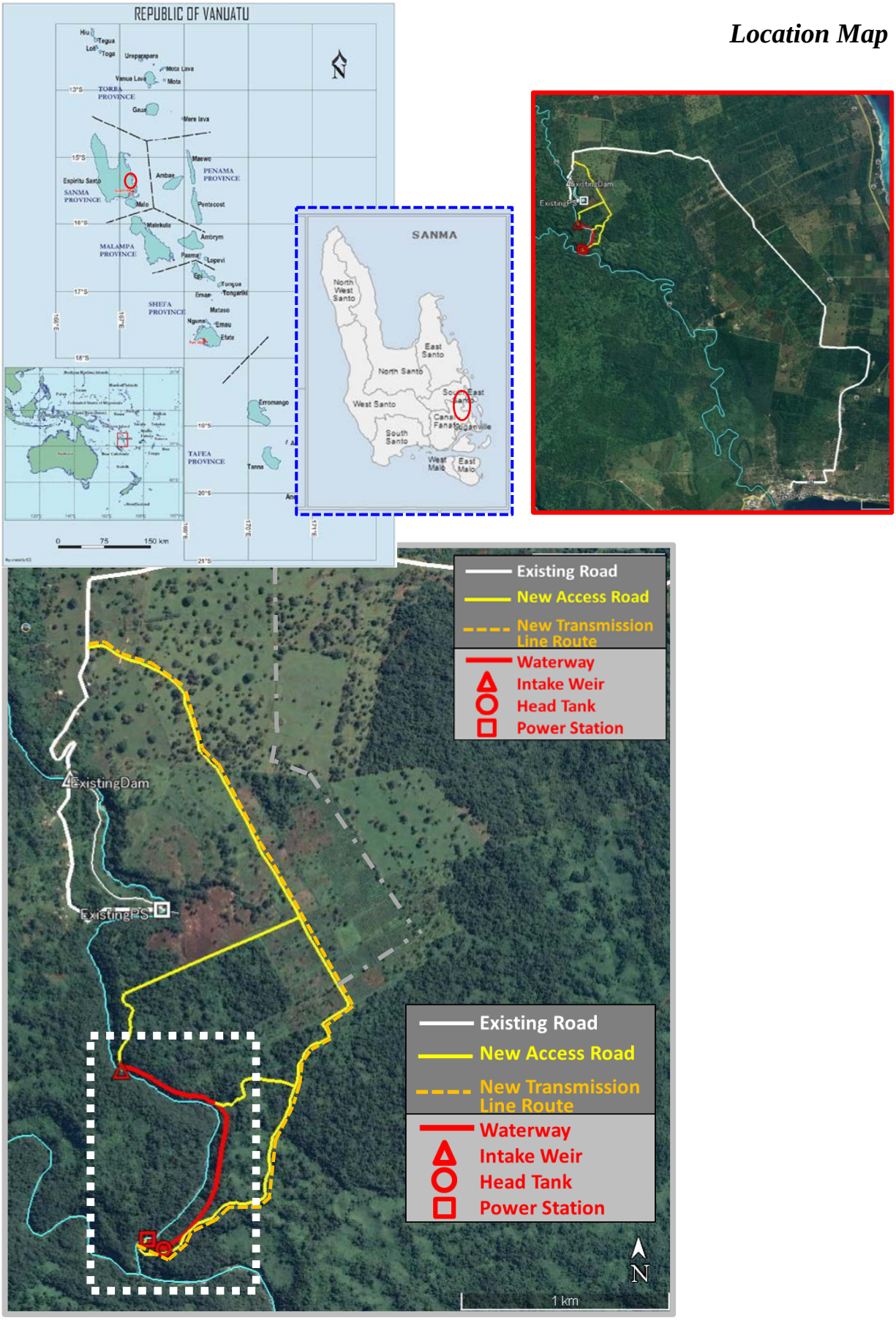

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Abbreviation

Symbol	Standard Nomenclature
ADB	Asian Development Bank
AE	Accredited Entity
CO_2	Carbon Dioxide
DEPC	Department of Environment Protection and Conservation
DGMMWR	Department of Geology, Mines, Minerals and Water Resources
DO	Dissolved Oxygen
DOE	Department of Energy
DOL	Department of Lands
E/N	Exchange of Note
EIA	Environmental Impact Assessment
EMA	External Monitoring Argent
EMMP	Environmental Management and Monitoring Plan
EPCA	Environmental Protection and Conservation Act
FUF	Flow Utilization Factor
G/A	Grant Agreement
GCF	Green Climate Fund
GHG	Greenhouse Gas
GL	Guideline
IMA	Internal Monitoring Argent
JICA	Japan International Cooperation Agency
LAP	Land Acquisition Plan
MALFFB	Ministry of Agriculture, Livestock, Forestry, Fisheries, and Biosecurity
MCCA	Ministry of Climate Change Adaptation, Meteorology, Geo-Hazards, Environment
MFEM	Ministry of Finance and Economic Management
MOL	Ministry of Land and Natural Resources
NAMA	Nationally Appropriate Mitigation Action
NDA	National Designated Authority
NEPIP	National Environment Policy and Implementation Plan
NERM	National Energy Road Map
NGEF	National Green Energy Fund
NSDP	National Sustainable Development Plan
OHSAS	Occupational Health and Safety Assessment Series
PAA	Priorities and Action Agenda
PEA	Preliminary Environmental Assessment
PRV	Plantation Russet Vanuatu
PV	Photovoltaic
QMP	Quarry Management Permit
RE	Renewable Energy
TOR	Terms of Reference
UNELCO	Union Electrique du Vanuatu Limited
URA	Utilities Regulatory Authority
VREP	Vanuatu Rural Electrification Project
VUI	Vanuatu Utilities and Infrastructure Limited
WB	World Bank
WHO	World Health Organization

Unit

Symbol	Abbreviation
%	percent
°	angle degree
°C	Celsius degree
cct	Circuit
cm	centi meter
g/cm^3	gram per cubic meter
GWh	giga watt hour
ha	hectare
hPa	hecto pascal
Hz	hertz
km	kilo meter
km^2	square kilometer
kV	kilo volt
kVA	kilo volt ampere
kW	kilo watt
kWh	kilo watt hour
mm	millimeter
m	meter
m^2	square meter
m^3	Cubic meter
m^3/s	Cubic meter per second
m/s	meter per second
km/h	kilometer per hour
masl	Meter Above Sea Level
mg/liter	milligram per liter
MCM	million cubic meter
MPa	mega pascal
MV	medium voltage
MVA	mega volt ampere
MW	mega watt
MWh	mega Watt hour
USD	United States Dollar
V	Volt
VUV	Vanuatu Vatu

1. Background of the Project

1.1 Background of the Project

The Government of Vanuatu (hereinafter referred to as "GOV") formulated National Sustainable Development Plan 2016 to 2030, which defined that the development shall be achieved with balance of three pillars of Society, Environment and Economy. In the Energy Sector, Updated Vanuatu Nation Energy Road Map 2016-2030 (hereinafter referred to as "Updated NERM") was issued in 2016. The overall vision of Updated NERM is to energize Vanuatu's growth and development through the provision of secure, affordable, widely accessible, high quality, and clean energy services. The following two projects in Espiritu Santo Island (hereinafter referred to as "Santo Island") are listed as the highest priority actions in Updated NERM 2016-2030.

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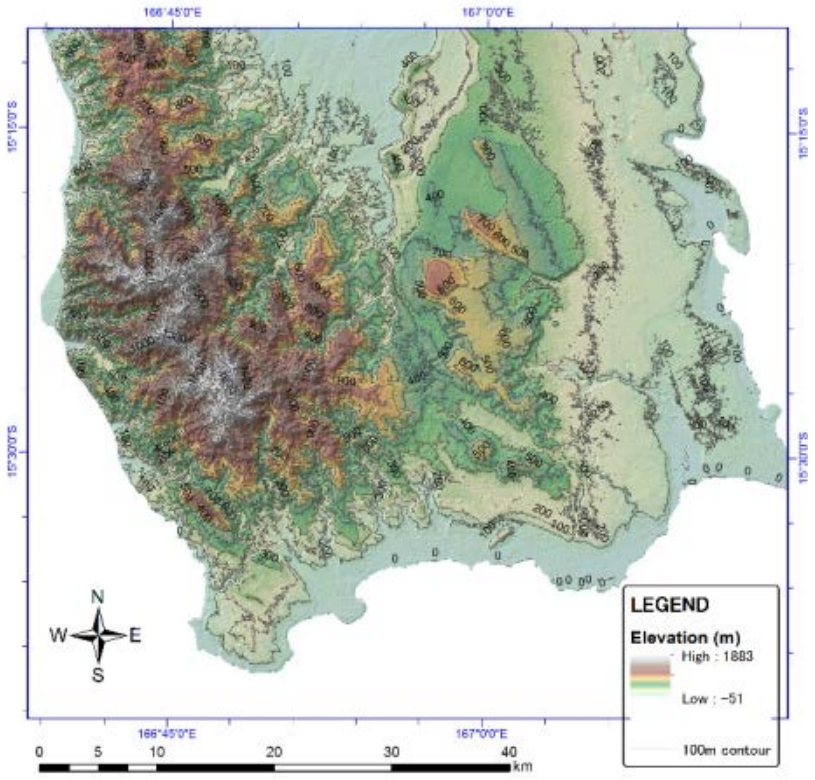
Based on these situations, "the Data Collection Survey on Electric Power Section in Espiritu Santo Island" was conducted by JICA in 2016 and 2017, which investigated potential of additional power generation projects by renewable energy in Santo Island. Based on the result of the survey, the Preparatory Survey (hereinafter referred to as "the Survey") for the Project for the Construction of Hydropower Station in Espiritu Santo Island (hereinafter referred to as "the Project") is conducted to examine feasibility of the Project as a Japanese Grant project.

1.2 Natural Conditions

In the island of the Espiritu Santo, Vanuatu, twin peninsulas protrude northward, but geological and topographic conditions are quite different between the eastern and western. The western part of island has pointed mountains of 1,800m in the highest elevation whereas the eastern part in which the project site is situated dominated of gentle hills of about 700m high at most (see Figure 1.2-1). Contour lines of 100m interval indicate that contours of 100 – 300m elevations run almost parallel to sea shore and incising hills is immature, thus it is considered that the most parts of the land below 300m in elevation are marine terraces and created in relatively later period of Quaternary. The hills scattered in narrow areas of 500 – 700m elevations in the eastern part of the island seem old terraces or basement rocks.

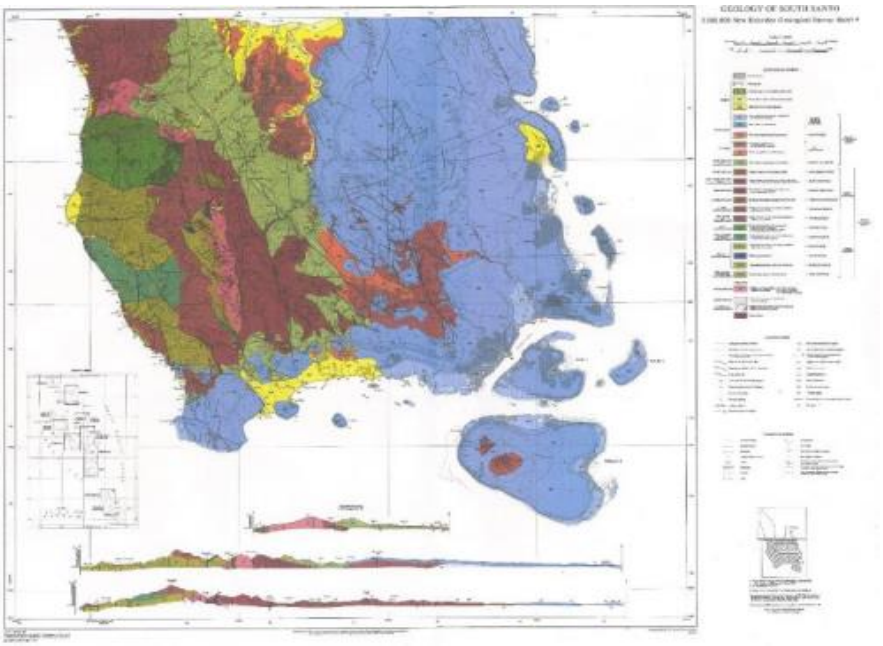
The mountains areas in the western part of the island consist of basement rocks of which volcanic products were erupted in Miocene (see Figure 1.2-2). The mountains have been incised remarkably and lost the primary shapes of volcano, hence volcanic activities might have been extinct before Quaternary. Figure 1.2-2 shows the terraces in the eastern part of the island uniformly consist of limestone originated from coral. It is thought that upheaval of crest around

hills of 500 - 700m elevations has continued during Quaternary period and coral areas have expanded toward east off shore. The Sarakata River and other few rivers in the eastern part of the island are thinly covered with sand and gravels supplied from coral limestone.



Source: Created with SRTM 30m DEM

Figure 1.2-1 Geomorphic Overview of the Espiritu Santo



Source: Geology of South Santo Scaled 1:100,000, British Government Ministry of Oversea Development, 1977

Figure 1.2-2 Regional Geology of the Espiritu Santo

1.2.1 Topography

The project site is located on the Sarakata River which incises marine terraces of 100 - 120m elevations. The surfaces of terraces are not utter flat in which the existing topographic map scaled 1:50,000 show, and actually show uneven with 10 - 20m of elevation gaps. The bumpy ground surfaces seem depressions unique to limestone area. Meteoric water percolates into underground through depressions rapidly, thus groundwater never springs in depressions or shallow valley on the terraces. Gentle hills on terraces are normally utilized with cattle ranches and plantation of palm trees and kavas (Photo 1.2-1 Grassland on Hills)

The Sarakata River forms cliffs of 5 - 30m high and steep slopes inclined over 45 degrees onto cliffs on the both banks. On the riverbed, there are many waterfalls of 1 – 3 m tall whereas sand bars are poorly developed (Photo 1.2-2). The main stream of the Sarakata River joins one of its tributaries at the downstream of approx. 3km from the existing Sarakata Power Station, and in the river section there are no streams and tributaries joining to the main stream although cliffs persist thoroughly on the both river sides (Photo 1.2-3).

In spite of steep slopes, tropical trees having prop roots, and some kinds of vine exuberate. On the other hand, soils on the slope compose clay mixing limestone gravels and grasses poorly grow. Hence ground on the slopes become muddy in rain falls. Unconsolidated soils seem run off easily because the effect of which vegetation ties soil particles into ground is poor (Photo 1.2-4, Photo 1.2-5).

Shallowly rugged hills utilized with cattle ranches and plantation of palm trees and kavas.

Photo 1.2-1 Grassland on Hills

There are many waterfalls of 1-3m tall, which are composed of coral limestone. Many small dents and bumps are in limestone surfaces. Sediments cover the river bed very thinly or almost not.

Photo 1.2-2 Waterfall on the Sarakata River

Cliffs alongside the Sarakata River extend for long section. The cliffs stand almost perpendicular in spite of soft siltstone like soil.

Photo 1.2-3 Cliff alongside the Sarakata River

Tropical trees stand with prop roots on steep slopes. Soil particles adhere the prop roots, hence it seems that soil erosion are being activated on the slopes.

Photo 1.2-4 Vegetation on a Steep Slope

1.2.2 Geology

(1) Geological Conditions on the Surface

On the riverbed on the Sarakata River coral limestone frequently forms small waterfalls. The limestone shows remnant of coral and has a lot of tiny voids in which polyps had lived for den. The bedrocks on the riverbed are hollowed at localities and irregular rugged surfaces are found occasionally (Photo 1.2-5). Medium hard rocks (compressive strength: over 25MPa) of limestone are distributed around the existing Sarakata Power Station, on the other hand, the limestone exposed in the proposed intake site is somewhat soft to be easily scarped by hammer pick.

The low cliff of the left bank neighboring the main stream expose siltstone in the proposed powerhouse site. The siltstone is easy to be stabbed with hammer pick but enough stiff not to allow deformation caused by pushing a finger (Photo 1.2-6).

Limestone shows remnant of coral such as irregular bumps and voids in which polyps had lived.

Photo 1.2-5 Limestone exposed on the Riverbed

Siltstone is stiffened but easy to be stabbed with a pick of hammer. Kneading rock on hands become easily liquefaction. Shrinkage cracks due to dry are found on outcrop surfaces.

Photo 1.2-6 Siltstone exposed on the River sides

(2) Geotechnical Issues

Figure 1.2-3 shows a conceptual layout of the new hydropower project. The geological profile along the intake weir axis is shown in Figure 1.2-4 and the profile between the powerhouse through head tank is shown in Figure 1.2-5. Topographic, geologic features and geotechnical issues of each hydraulic structure are mentioned below.

1) Intake Weir

The intake is laid out on a valley of about 25m wide. The riverbed exposes soft coral limestone continuously from the upstream to downstream. The cross profile of the valley indicates asymmetry between left and right banks. The slope of the left bank inclines with 45 degree below at 115m in elevation although the slope of the right bank shows very steep to be inclined with over 60 degrees. According to the exploratory drilling result at DB-1, subsurface in vicinity of the riverbed consists of residual soil of limestone with lower than 5 of N-values up to 2m in depth. The unconsolidated residual soil is assumed to reach to 4m deep on gentle slope of the left bank. Gravelly limestone of N-values more than 10 appears at 2m deeper portions of DB-1. These gravelly rocks are probably same one

exposed on the riverbed. N-values at DB-1 fluctuate but tend to rise higher at deeper portions, and exceed 20 at 8m deep. At deeper than 14m, siltstone appears and its N-values exceed 50 in which ground has sufficient strength capable for placing of intake weir. However it is not realistic to excavate grout up to the surface of siltstone. Height of the intake weir is shorter than 10m hence the ground having 20 of N-value will possibly underpin the weir with no trouble.

2) Headrace

Exploratory drillings at WB-1 to 5 show an assumption that steep slopes in which headrace conduit will pass through consist of gravelly limestone uniformly. N-values vary among the drilling holes but are higher than 10 at 1m deeper, in common. However drilling holes higher than 20 of N-values within 10m in depth are only WB-3 and WB-5. Therefore the ground of steep slope on the headrace alignment ranges 10 - 20 of N-values.

Natural slopes are stable at inclination of about 60 degrees. Therefore appropriate slope protection will ensure stable even steep gradient of 0.5 horizontal to 1 vertical. However groundwater tables at WB-2, 3, 4 lie on 2 - 3m deep, so drainage holes on cut slopes are necessary.

It is afraid that erosion and shallow collapse possibly will possibly be induced on naked slope faces due to gravelly limestone, and eroded soil drops into the conduit. Box culvert is hopeful in order to prevent soil invasion into the waterway. However box culvert in all sections of the headrace is large burden on construction cost. The sections of box culvert should be appropriately chosen based on the both sides of technical and cost effective.

A meander part of the Sarakata River under the waterway is the severest location of slope erosion. Thus a shore protection work such as gabion wall is required to be set at foot of the slope.

3) Head Tank & Penstock

As shown in Figure 1.2-5, at HB-1 coral limestone appears as shallower portions 11m in depth, but sandstone less strength than the shallower limestone underlies at deeper portions. The limestone with 30 of N-values at shallow portions dominates 3m deep. It is no problem to take the limestone for foundation of the head tank and anchor blocks.

At PB-3 in which an anchor block at the lower part of the penstock is located, N-values exceed 10 at 2m deep but certainly exceed 20 at 12m deep.

4) Powerhouse

The powerhouse site is located on the narrow terrace created by the Sarakata River. Siltstone outcrops are exposed on the riverside. Drillings of PB-2 and PB-3 uncovers that massive siltstone continues at 30m deep at least. The siltstone may possibly exceed 50 of N-values at very deep portions, but not under 20 even at shallow portions.

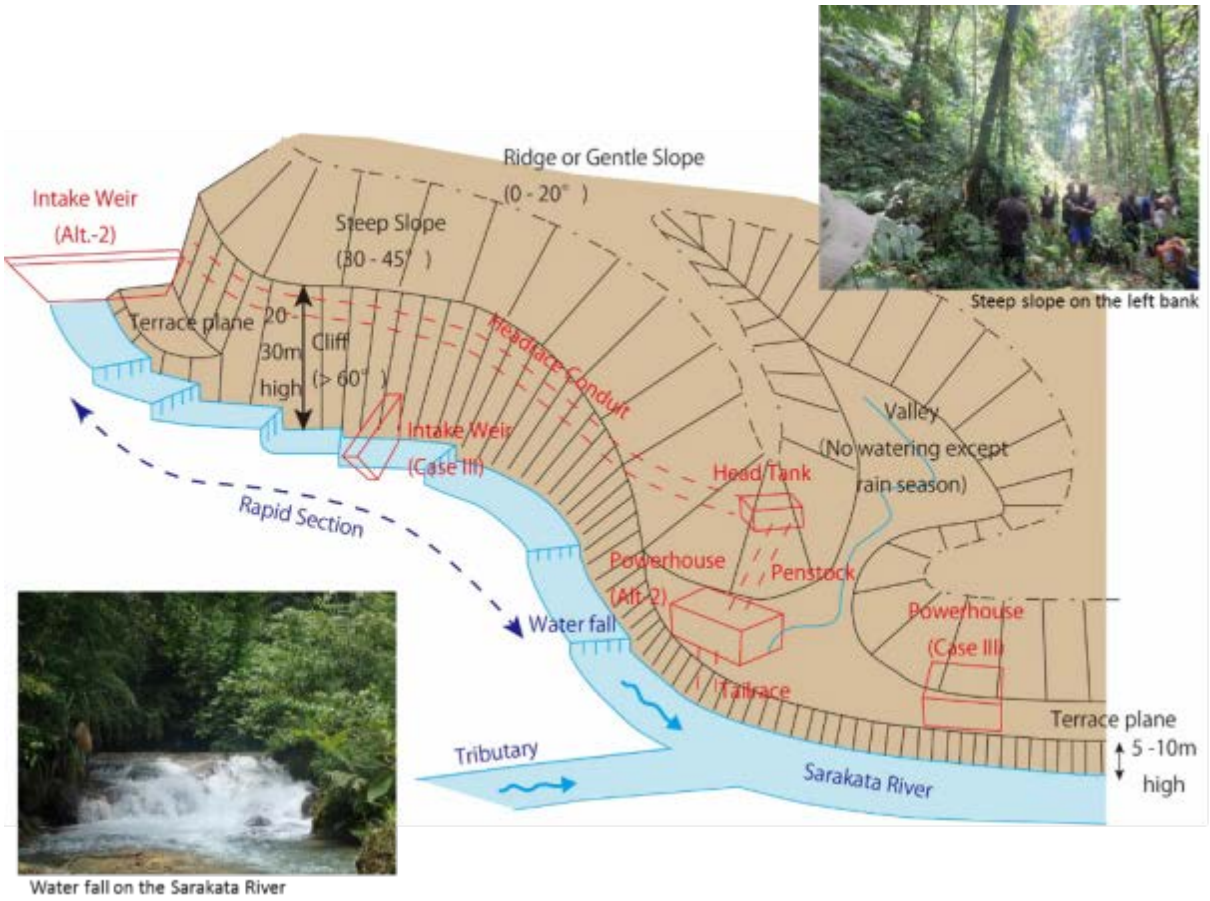


Figure 1.2-3 Conceptual Layout of the Hydropower Project

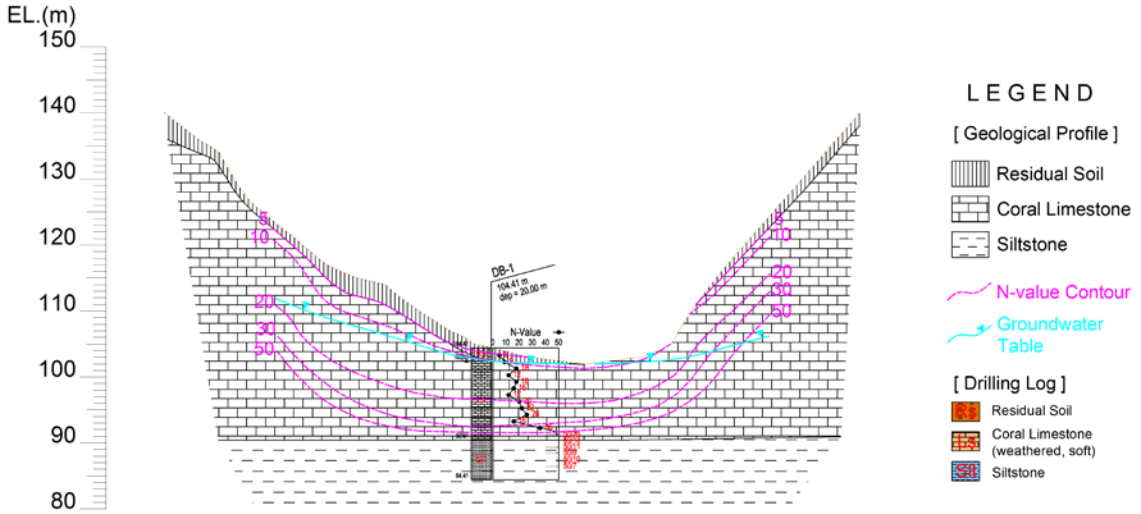


Figure 1.2-4 Geological Profile along the Axis of Intake Weir

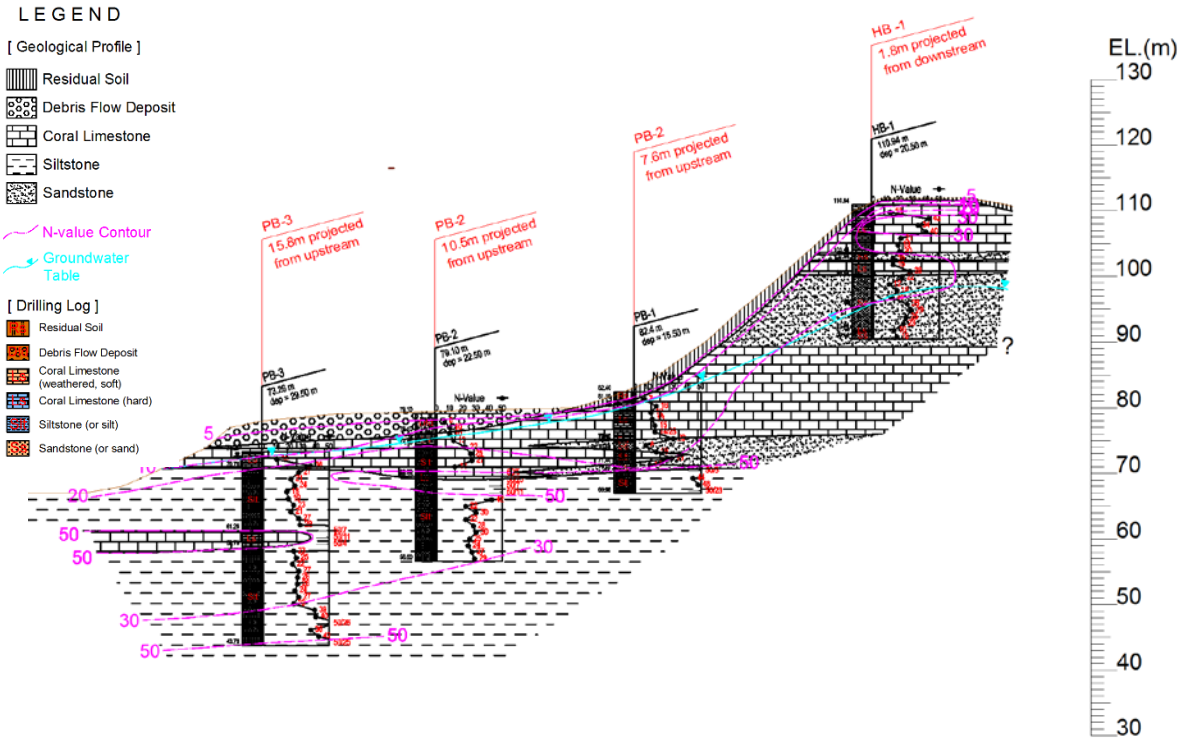


Figure 1.2-5 Geological Profile between the Powerhouse and Head Tank

1.2.3 Hydrology

(1) Temperature and Humidity

The climate at the Sarakata Hydroelectric power station is generally hot and humid with an average temperature and humidity of 25.6 degree and 83% respectively according to the observation record at Pekoa Airport which is located close to the downstream of Sarakata River. Therefore, it has to be made sure that failures of the power station and the substation caused by condensation does not occur.

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max Temp (° C)	30.3	30.4	30.2	29.6	28.7	27.9	27.4	27.5	28	28.7	29.4	30.1	**29.0**
Mean	26.6	26.7	26.6	26.2	25.5	24.8	24.4	24.3	24.6	25.3	25.9	26.3	**25.6**
Min Temp (° C)	22.8	22.9	22.9	22.8	22.3	21.7	21.3	21	21.2	21.8	22.4	22.5	**22.1**

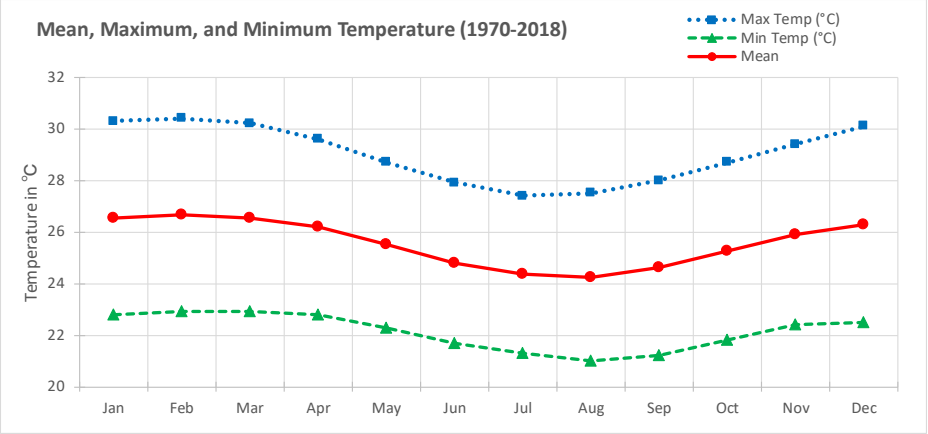


Figure 1.2-6 Temperature at Pekoa Airport

(2) Rainfall

The region has a tropical rainforest climate and the seasons are clearly divided into rainy season from May to October and dry season from November to April. The average annual rainfall is approximately 2,300 mm/year, and cyclones with heavy rain and wind occur during the rainy season. Therefore, measures for sufficient drainage against strong rainfall should be considered while designing the civil facilities. Furthermore, measures should be taken to prevent the lightning from damaging the equipment.

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Pekoa	309	307	289	258	243	188	110	99	118	169	195	205	**2,491**
Fanafo	328	258	412	421	256	192	123	79	199	257	314	297	**3,135**

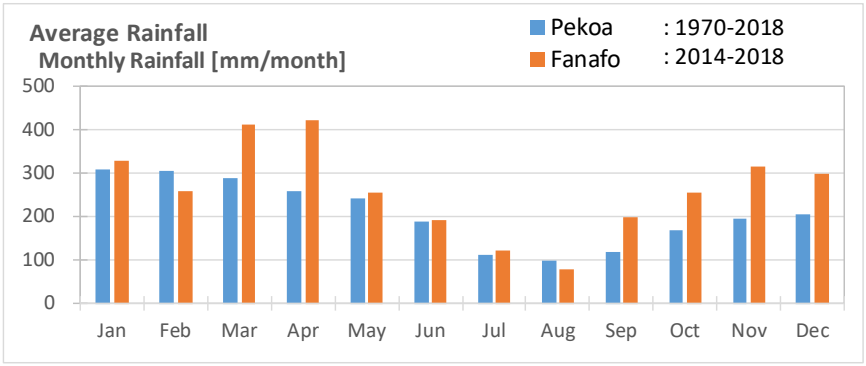


Figure 1.2-7 Monthly Average Rainfall

(3) River Discharge

River discharge of the Sarakata River was estimated based on the operation record of the existing Sarakata Hydropower Station after the confirmation by comparing estimated discharge based on operation record and discharge measurement record.

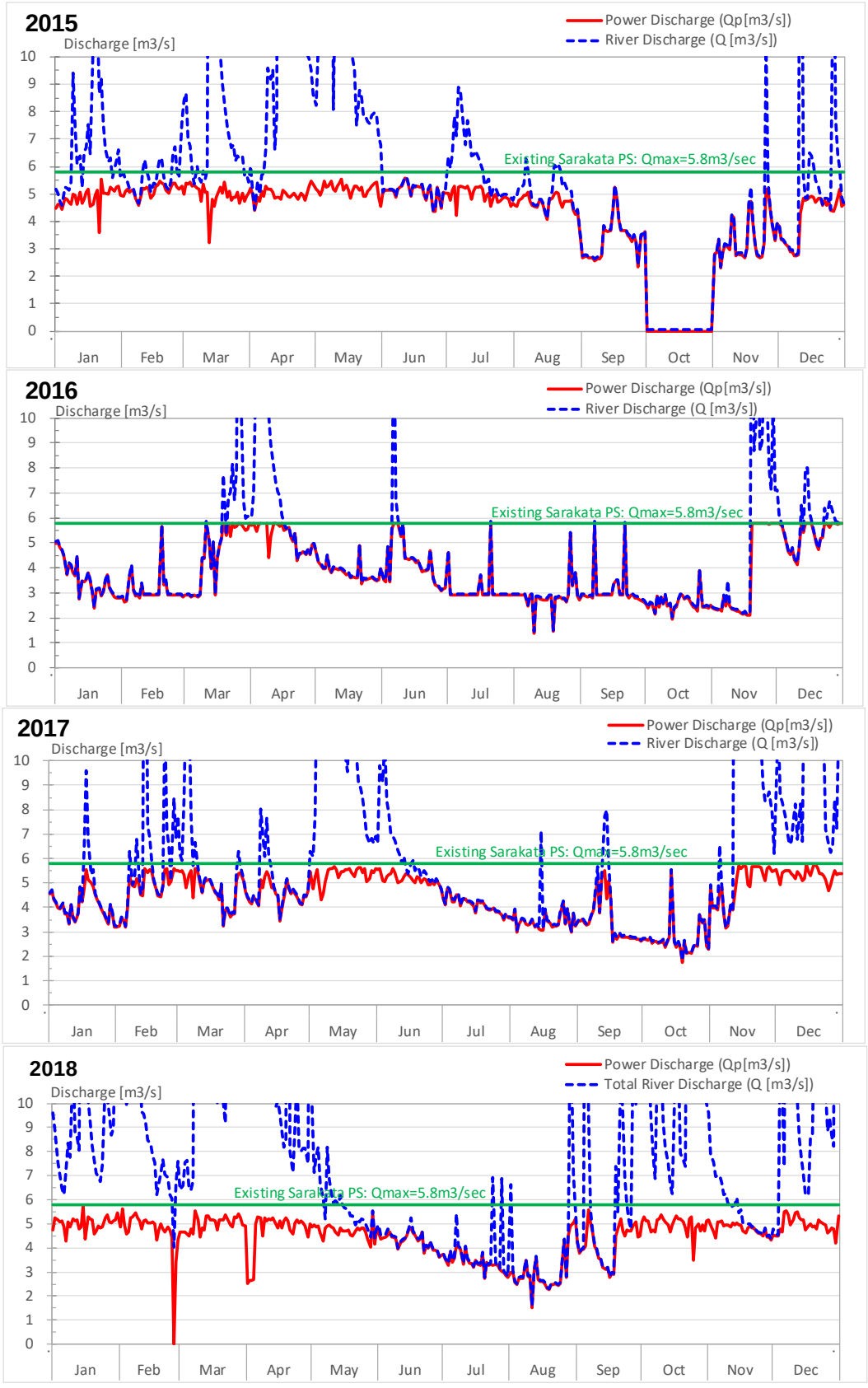


Figure 1.2-8 Daily River Discharge and Power Discharge

Table 1.2-1 Monthly Average River Discharge

	2015	2016	2017	2018	Ave.2015-2018	Max.2015-2018	Min.2015-2018
Jan	6.9	3.6	4.4	9.7	6.2	9.7	3.6
Feb	5.6	3.1	6.2	16.7	7.9	16.7	3.1
Mar	9.7	5.7	5.8	14.9	9.0	14.9	5.7
Apr	19.4	10.3	4.9	13.5	12.0	19.4	4.9
May	12.7	3.9	15.2	5.9	9.4	15.2	3.9
Jun		4.6	6.3	4.4	5.1	6.3	4.4
Jul	6.1	3.1	4.1	3.7	4.3	6.1	3.1
Aug	5.1	2.9	3.6	3.6	3.8	5.1	2.9
Sep	3.4	3.2	3.8	7.8	4.5	7.8	3.2
Oct		2.6	2.7	14.9	6.8	14.9	2.6
Nov	3.7	5.7	14.2	5.7	7.3	14.2	3.7
Dec	5.6	5.8	10.3	15.6	9.3	15.6	5.6
Average	7.8	4.5	6.8	9.7	7.2	19.4	2.6
Average in rainy season	8.5	5.7	7.6	12.7	8.6	19.4	4.4
Average in dry season	6.8	3.4	6.0	6.7	5.7	15.2	2.6

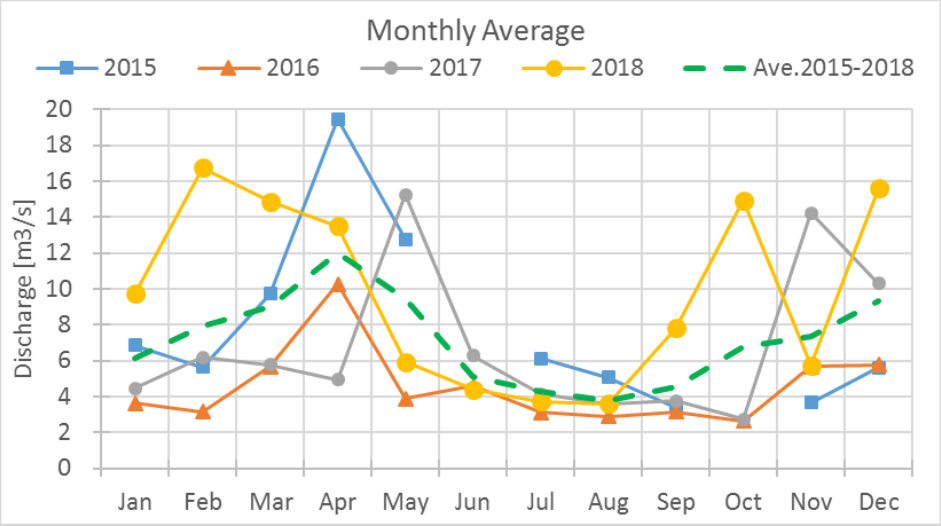
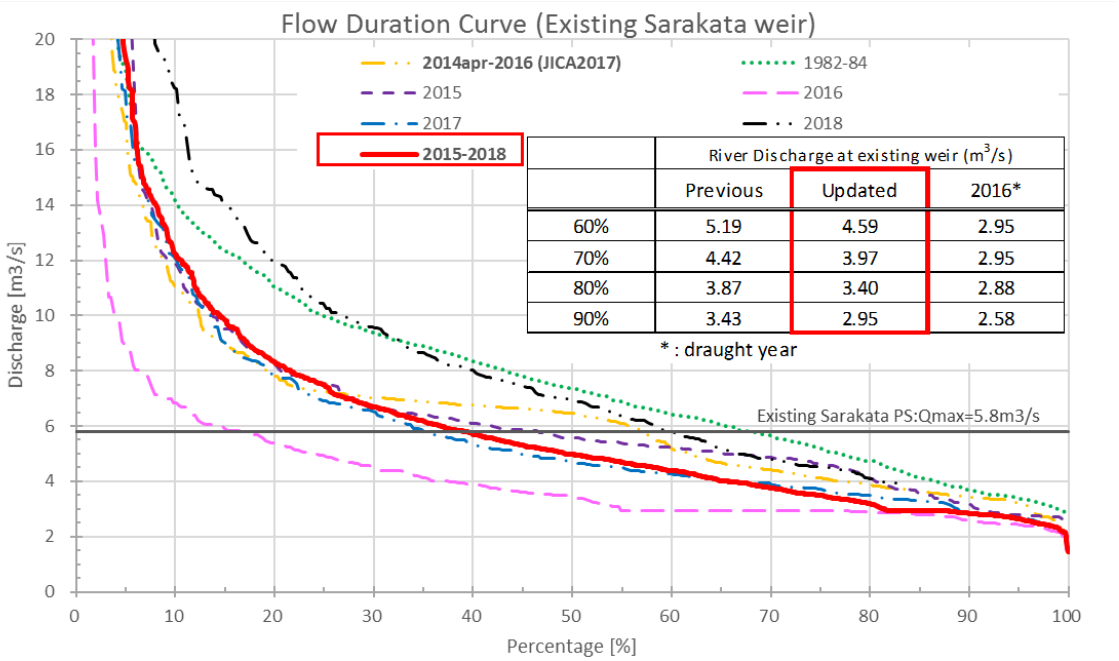


Figure 1.2-9 Monthly Average Discharge

(4) Flow Duration Curve

Based on the daily river discharge, the flow duration curve for establishing the hydropower planning was obtained.



	River Discharge at existing weir (m^3/s)		
	Previous	Updated	2016*
60%	5.19	4.59	2.95
70%	4.42	3.97	2.95
80%	3.87	3.40	2.88
90%	3.43	2.95	2.58

Figure 1.2-10 Flow Duration Curve

(5) Design Flood

The design discharge was estimated based on the 47-year rainfall record of Pekoa from 1970 to 2018. The probable rainfall of Fanafo (5-year record from 2014 to 2018) as well as Pekoa was shown below.

Table 1.2-2 Probable Rainfall (Pekoa, Fanafo) and Design Discharge

Return Period / Station	1/10	1/20	1/50	1/100	1/200
Pekoa [mm/day]	255	295	347	386	425
Fanafo [mm/day]	254	279	311	336	360
Probable Flood Discharge [m^3/s]	350	400	520	610	670

1.3 Environmental and Social Consideration

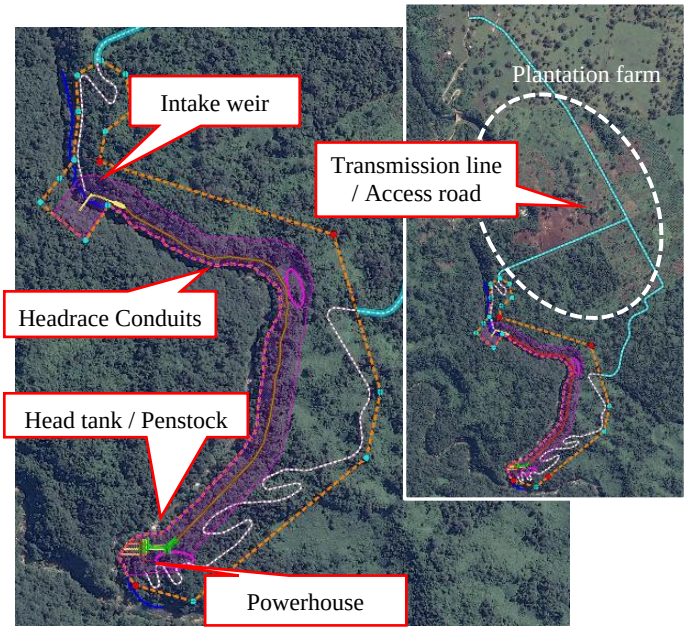
1.3.1 Environmental and Social Impact Assessment

1.3.1.1 Outline of Project Components that have Environmental and Social

Project Components that have Environmental and Social Impacts are construction of hydropower facilities, transmission line facilities and access road as follows. Main are of the project site is farm land of a plantation company (Plantations Réunies de Vanuatu: PRV).

1) Hydropower facilities (500kW × 2 = 1,000kW)

- ✓ Hydraulic Turbine / Generator / Protection & Control units
- ✓ Intake Weir)
- ✓ Intake and Stilling Basin
- ✓ Headrace Conduits
- ✓ Head Tank
- ✓ Anchor blocks, Saddles
- ✓ Penstock
- ✓ Building of Powerhouse
- ✓ Tailrace



2) Transmission line facilities

- ✓ Electrical Poles
- ✓ Conductor (20kV, 6km)
- ✓ Transformer

3) Access road

- ✓ Access road from the existing road to construction site (6.2km)

1.3.1.2 Current Environmental and Social Condition

(1) Natural Condition

1) Climate

The Espiritu Santo Island is located at the Northern part of Vanuatu and has wet tropical climate. Average temperatures range from between 21°C and 27°C, and the average humidity ranges between 75% and 80%, and temperatures vary slightly for the dry season (from July to September) and the wet season (from November to April). The warmest months are January-March and the coolest are July to September. The mean annual rainfall at Luganville (Pekoa Airport Gauging Station) over the 43-year period 1971 - 2013 is 2,401 mm and the range of annual rainfall maxima over that period shows significant variability with an annual maximum of 3,474 mm (1988) and a minimum of 689 mm (1983).

Rainfall is associated with the monsoon winds, which change direction due to the movement of the inter-tropical convergence zone in winter and summer. In the summer (wet season) months of October to April, the north-easterly wind conditions bring warm humid airstreams, and the associated cyclonic disturbances. During this period, about 68% of the annual rainfall is recorded. From May to September (dry season) the south-easterly trade winds affect the country. Every year, the month of August is experienced as the driest month.

2) Topography, Geology and Soils

Espiritu Santo Island is the largest island in the Vanuatu with approximately 3,900 km2 area. The island has two main geomorphic features. The first is a deeply dissected western mountain range of volcanic and volcanoclastic rocks extending from the northern end of the Cumberland Peninsula to the southwest tip of the island, which also includes Vanuatu's

highest mountain Mt Tabwemasana at 1,879 m. The second feature is an eastern reef limestone plateau comprising a series of terraces. The limestone terraces also form a fringe along the southern margin of the island.

The limestones are overlain by thick clay soils and only locally by small amounts of river and coastal alluvium. The soil cover on the limestone is due to the ash from the nearby volcanoes, which occurred in the past. The soil is mature and it is comprised of light brown clay showing relict tuffaceous texture with increasing thickness with altitude of the limestone.

The volcanic mountains of Espiritu Santo and Malekula are overlain by shallow, less mature, but generally fertile, volcanic soils. Soils developed on alluvium are immature but fertile and low in potassium. The project area is located within the limestone plateau. The Sarakata River drains the eastern limestone plateau and meanders to the south of Luganville[1].

3) Ecosystem

Santo island has a forest cover of approximately 285,530 ha (2010), and it is also home for the endemic plants and animal species in Vanuatu. It has a mid-height forest with close and open canopy, which is the most prominent forest type in the country with high ecological and forest commercial values and is predominant mostly in the areas of higher altitude (300m>) especially the West coast peninsula. The same forest type that exist on the Eastern part of the island has lost its forest structure due to logging operations, and has been reclassified as thickets. Low forest type is usually comprised of mix hardwood species and predominant mostly in the areas of lower altitude (300m<) around the island, and the upper slopes towards the ridges are usually covered with shrubs and grass. The lower laying areas along the coast of the island have been converted to lands for various uses and settlement[2].

Complex vine forest and scrub around the project site are the most widely distributed lowland rain forest type in Santo Island. It is in various stages of recovery following the disturbances caused by cyclones and human activities, and it is interpreted as a secondary successional vegetation in different stages of adjustment to the prevailing rainforest climate. More than 80 percent of the project area has been disturbed through logging practices, continuous clearing of land for gardening activities (mainly kava, coconut and cattle farming) and cutting of trees and bamboos for house materials.

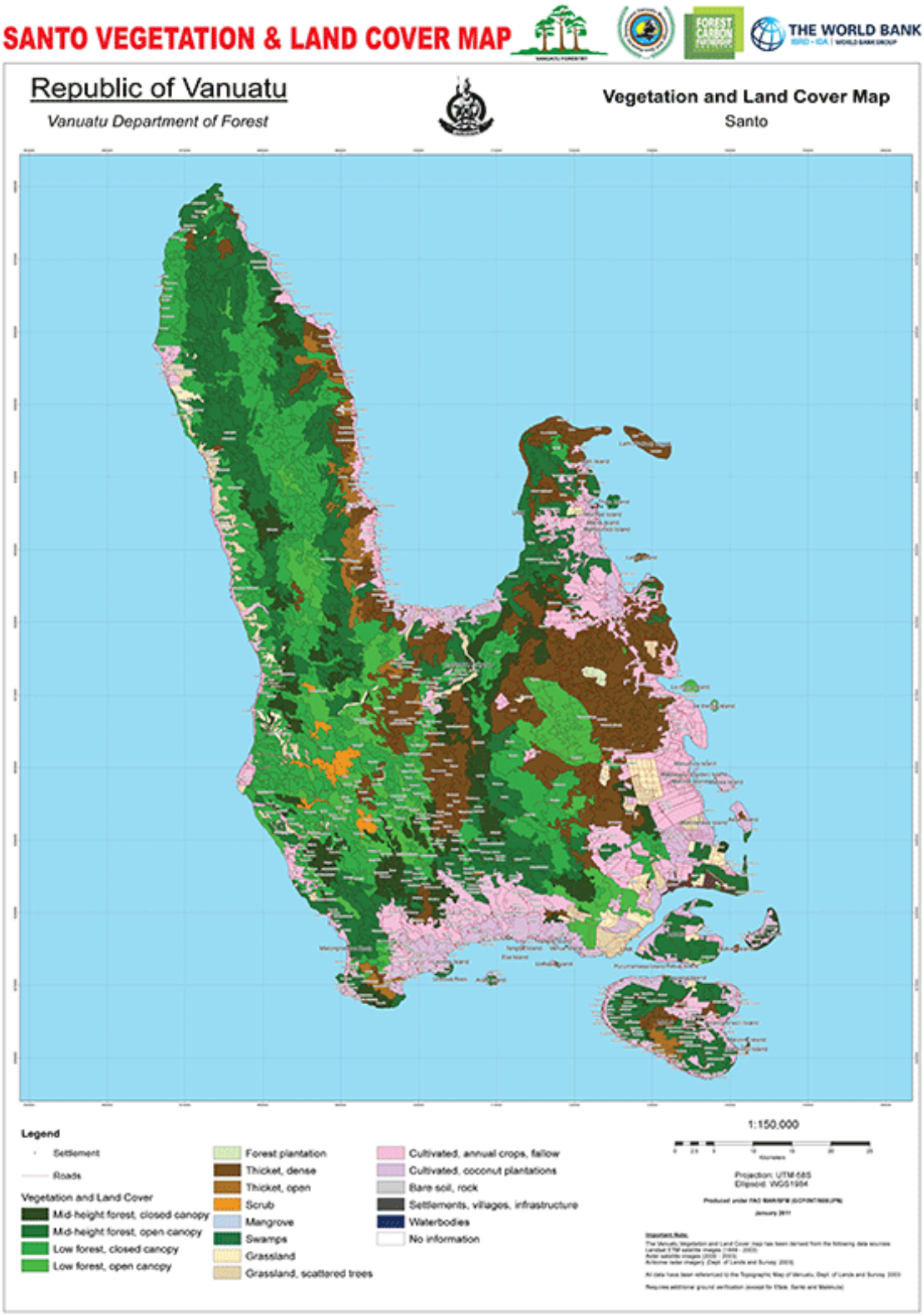
Result of the baseline survey for ecosystem including site survey and literature survey is as follows. Vulnerable specie were identified but possibility that risk for species is increased by the project may not be big, and mitigation measure will be implemented for the species as needed.

1 TA-8285-VAN: Energy Access Project 1. Vol.3 Feasibility Study of Sarakata 1 Extension Project
2 Vanuatu National REDD + Programme, Department of Forestry, Port Vila

Table 1.3-1 Plant life

Species Name	Native or Endemic	Introduced or Invasive
Meremia peltate		Invasive
Mucuna		
Kleinhovia hospita	Native	
Intsia bijuga	Native	
Gyrocarpus americanus	Native	
Diospyros acris		
Syzygium sp		
Garcinia pancheri		
Myristica fatua	Native	
Terminalia	Native	
Tieghemopanax		
Veitchia palms		
Tectaria		
Asplenium		
Selaginella		
Pterocarpus indicus (Rosewood)	Native	
Dracontomelon vitiensis (Nakatambol)	Native	
Antiaris toxicaria (Melek tri)	Native	
Castanospermum australe (Black bin)		
Endospermum medullosum (Whitewood)	Native	
Pometia pinnata (Nandau)	Native	
Merremia peltata		Invasive
Micania micarantha		Invasive
Solanum torvum		Invasive
Denstalia species		
Heliconia indica	Native	
Acerratium opositifolia		
Burckella obovata	Native	
Pangium edule	Native	
Cupaniopsis neo-ebudicum	Endemic This is an endemic specy in Vanuatu and lives on whole area in Santo. There is little possible that this faces a large risk by the Project.	
Dysoxylum aneityensis		
Elaeocarpus floridanus		
Evodia sp		
Palaquim neo-ebudicum		
Semecarpus vitiense		
Terminalia sepicana		

Photo 1.3-1 Disturbed areas covered predominantly by the invasive fine, Meremia peltata



Source: Vanuatu National REDD+ Programme
http://reddplus.vu/vanuatu-national-redd-program/redd-selected-islands/santo/

Figure 1.3-1 Santo Vegetation and Land Cover Map

Table 1.3-2 Animal life

Species Name	Common Name	Conservation Status	Habitats
Birds			
Aerodramus vanikorensis	Uniform Swiftlet	Least Concern	Seen on grasses along roadside and in the villages. It is very common in cleared areas
Chalcophaps indica	Green-winged round Dove	Least Concern	In flight in coconut and kava plantations and walk in cleared areas
Columba vitiensis	Whitethroat Pigeon	Least Concern	Heard calling in primary forest along the ridge of the river
Collocalia esculenta	Whitebellied swiftlet	Least Concern	Seen on grasses along roadside and in the villages. It is very common in cleared areas
Ducula pacifica	Pacific Imperial	Least Concern	Heard calling in primary forest along the ridge of the river
Halcyon chloris	White Collarded Kingfisher	Least Concern	Seen around the villages and in coconut and kava plantations
Falco pereginus	Pereginus Falcon	Least Concern	Seen flying above the tree forest canopy above the river
Gallirallus philippensis	Banded Bus Rail	Least Concern	Seen in cleared areas mainly in coconut and kava plantations.
Megapodius freycine	Incubator Bird	Least Concern	Reported by locals
Ptilinopus greyii	Red-bellied Fruit Dove,	Least Concern	Reported by locals
Zosterops Lichmera incana	Silver-eared Honeyeater,	Least Concern	Seen in cleared areas mainly in coconut and kava plantations.
Reptiles			
Emoia caeruleocauda	Pacific Bluetail Skink	Least Concern	Seen in abundance along the tracks of the site in forest
Emoia cyanogaster	Green-bellied skink	Least Concern	Seen in abundance along the tracks in forest among dry leaves and on fern leaves
Emoia impar	Blue-tailed skink	Least Concern	Seen in abundance in cleared areas
*Emoia sanford*i	Vanuatu Green Tree Skink	Least Concern	Seen climbing on tree in cleared area
Emoia nigromarginata	Black-friged skink	Least Concern	Seen among dry leaves in forest
Candoia bibroni	Pacific boa	Least Concern	Seen on a tree branch on cleared track of the site in forest
Mammals			
Pteropus. anetianus	Vanuatu Flying Fox	Vulnerable	This may be a partly diurnal species. Animals generally spend the day in small, quiet colonies. It has been found feeding on figs, breadfruit, and coconuts. Births are believed to take place in August and September. This is an endemic specy in Vanuatu and lives on many islands in Vanuatu. There is little possible that this faces a large risk by the Project but mitigation measures should be implemented.
Pteropus tonganus	Pacific Flying Fox	Least Concern	This species is usually found in large roosting colonies in large, canopy trees. It has been recorded in tropical moist forest, mangrove forest, and feeding on plantation crops such as banana and papaw.
Miniopterus macrocneme	Small Melanesian Bent-winged Bat	Least Concern	This species is found from lowland tropical forest habitats to subalpine grasslands, and is more common at the higher elevations.
Rattus exulans	Polynesian Rat	Least Concern	This species is present in a wide variety of habitats, including disturbed or agricultural land.
Miniopterus australis	Little Bent-winged Bat	Least Concern	This species roosts in colonies in caves and tunnels, stormwater drains, and sometimes buildings. There have been observations of occasional roosts in tree hollows.
Miniopterus tristis	Great Long-fingered Bat	Least Concern	This species forages for insects in open areas and above the forest canopy, in primary and secondary forest, and also agricultural areas
Aselliscus tricuspidatus	Trident Leaf-nosed Bat	Least Concern	This species has been recorded roosting in many caves and tunnels.

Species Name	Common Name	Conservation Status	Habitats
Amphibians			
Litoria aurea	Yellow Bellied Frog	Vulnerable	Seen in water puddles in kava plantation and the project site. Despite the situation in Australia that this specy is decreasing, this remains abundant in several other Pacific Islands including Vanuatu where it was introduced in the 19th century.
Fishes			
Mesopristes argenteus	Silver grunter	Least Concern	Lower sections of streams and inland deep stream pool
Khulia rupestris	Jungle perch	Least Concern	Across Vanuatu, in the lower streams but travels between freshwater and marine waters
Khulia munda	Perch species	-	Coastal reaches of streams and estuaries across Vanuatu
Caranx sexfasciatus	Bigeye trevally	Least Concern	Freshwater and marine water on Santo and Malekula islands
Lutjanus argentumaculatus	Mangrove red snapper	Least Concern	Found in the coastal reaches of rivers and mangroves on Santo, Efate, Erromango and Malekule islands
Lutjanus fuscescens	Spotted bass	-	In Vanuatu it is found only on Santo Island. It is a marine species in its adult form but juveniles and subadults favour estuaries or lower sections of freshwater streams
Monodactylus argenteus	Silver-moon fish	Least Concern	In Vanuatu it is found only on Santo, commonly in mangroves but also entering small creeks
Cestraceus plicatilis	Black Mullet	-	In Vanuatu it is found on Santo, Maewo and Pentecost and are common in large streams
Macrobrachium gracilirostre		Least Concern	All streams throughout Vanuatu.
Macrobrachium latimanus		Least Concern	All streams throughout Vanuatu in the upper reaches.
Macrobrachium austral		Least Concern	All streams throughout Vanuatu in the lower reaches.
Macrobrachium lepiactyloides		Least Concern	Santo and Malekula islands. It is common in large streams near the coast.
Macrobrachium latidactylus		Least Concern	Santo and Malekula islands in the lower part of large sandy/gravel bottomed streams.
Anguilla marmorata	Giant long-finned eel	Least Concern	All streams and rivers throughout Vanuatu. This eels lives in freshwater as an adult and in estuaries and seas as a juvenile.
Anguilla magostoma	Pacific long-finned eel	-	Santo, Malekula, Gaua and Aneityum islands in all parts of streams.
Anguilla obscura	Pacific short-finned eel	-	Santo and Gaua islands in estuaries and inland lakes.

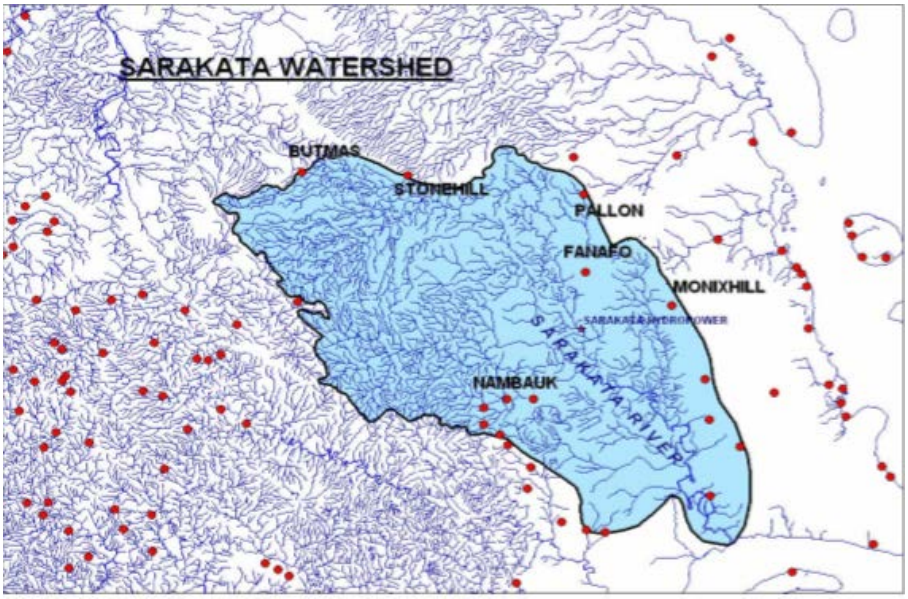
Source: IUCN RED LIST and site survey

Photo 1.3-2 Wild pig's footprint and Juvenile tree snake (Candia bibroni)

4) Hydrological Situation

The Sarakata River is a large river located in the southeast of Santo Island close to the Sanma provincial capital of Luganville and provides abundant water resources for the island's population. Sarakata River has important role in water supply and the existing Sarakata hydropower generation in and around Luganville.

The Sarakata River rises in the high mountain lands in the center of the island at around 784 m falling moderately at around 3.6% gradient in the east, and then it flows in the southerly direction over 18.8 km reaching the existing Sarakata hydropower plant at an altitude of 110 m. The catchment area of 97.1 km^2 has moderate to heavy forest cover and the land use in this area is limited to animal grazing, kava and coconut farming and forest hunting and foraging. The catchment is complex with multiple incised channels and stream threads. Flood peaks are sharp and the storm runoff declines rapidly as the surface runoff appears to infiltrate into subterranean storage for slow release during the dry season.



Source: IWRM Sustainable Management of Sarakata Watershed

Figure 1.3-2 Sarakata Watershed (Red dots are communities)

(2) Social Condition

1) Population

Most of the population of the Santo Island is rural, although Luganville has a sizable population. Sanma's population pyramid illustrates a triangular shape with forty percent of the population made up of young people under the age of 15 years and about a quarter of Sanma population is between the age of 15-29 years, and the percentage keeps decreasing as the age increases. Age group by sex shows that in Santo, there are more males compared to

Table 1.3-3 Population in Santo island

Area	Population	Rate
Northwest Santo	1,554	3%
North Santo	4,615	10%
West Santo	2,930	6%
South Santo	8,120	17%
East Santo	4,463	9%
South East Santo	5,641	12%
Canal-Fanafo	4,711	10%
Luganville	15,865	33%
Total Population	47,899[1]	100%

Source: 2016 Post Pam Mini Census Report

females.

The population trend is same for Canal-Fanafo including the project site. The percentage keeps decreasing as the age increases, and the age group by sex shows that there are more males compared to females.

Table 1.3-4 Age group and sex rate in Santo island and Canal-Fanafo area

Age group	Santo island			Canal-Fanafo		
	Population	Male	Female	Population	Male	Female
0-14	19,043	52.4%	47.6%	1,935	53.1%	46.9%
15-29	13,104	48.3%	51.7%	1,255	50.5%	49.5%
30-49	10,439	51.5%	48.5%	1,007	55.3%	44.7%
50+	5,313	53.4%	46.6%	514	55.6%	44.4%
Total	**47,899**	**51.2%**	**48.8%**	**4,711**	53.2%	46.8%

Source: 2016 Post Pam Mini Census Report

2) Local Economy

According to the Household Income and Expenditure Survey Report 2010, the average monthly income of Sanma households was 94,000 VUV with an average per capita income of 18,800 VUV. Approximately 58% of household income is from cash sources; and, 26% of total household expenditure is in cash. On the other hand, Luganville households have comparatively a lower average household monthly income of 74,100 VUV compared to the province; likewise its average per capita monthly income is much lower at 13,200 VUV.

Main source of household income in both the Santo Island and Canal-Fanafo area is the sale of fish/crops/handicrafts as shown below, and the rate in Canal-Fanafo area is larger than the rate in Santo Island.

According to an interview in Fanafo village located near the existing hydro power station, one household sells kava of about 100kg/month at the market in Luganville and its cash income is VUV 50,000~90,000/month[3].

Table 1.3-5 Main source of household income in Santo island and Canal-Fanafo

Area	Wages/ salary	Land lease	Remittances	House rent	Sale of fish/ crops/ handicrafts	Own business	Others	None
Santo	30.3%	0.6%	2.9%	1.1%	39.3%	19.7%	5.5%	0.7%
Canal-Fanafo	25.7%	2.0%	2.7%	0.2%	53.7%	11.8%	3.8%	0.1%

Source: 2016 Post Pam Mini Census Report

3) Social Infrastructures

12% households in Canal-Fanafo do not have access to an improved drinking water source. For the Household, the main source of drinking water is rainwater and its rate are larger than in the Santo Island.

3 Data collection survey on power sector in Espiritu Santo in Republic of Vanuatu Final Report

Table 1.3-6 Household main source of drinking water in Santo island and Canal-Fanafo

Area	Rainwater tank	Pipe	Surface water	Underground well	Bottle water	Other
Santo	40.1%	44.9%	12.8%	1.9%	0.2%	0.1%
Canal-Fanafo	55.9%	31.9%	8.7%	3.4%	0%	0.1%

Source: 2016 Post Pam Mini Census Report

Regarding energy, the main lighting source for household is mostly solar power in both Santo Island and Canal-Fanafo.

Table 1.3-7 Household main lighting source in Santo island and Canal-Fanafo

Area	Solar	Electricity	Battery lamp	Generator	Other
Santo	64.0%	31.9%	1.9%	1.6%	0.6%
Canal-Fanafo	67.1%	27.2%	3.1%	2.4%	0.2%

Source: 2016 Post Pam Mini Census Report

4) Gender/ Children's right

The National Sustainable Development Plan (NSDP) 2016-2030 (The People's Plan) recognizes the importance of an inclusive society which upholds human dignity and the rights of all Ni-Vanuatu including women, youth, the elderly and vulnerable groups are supported, protected and promoted. Among the policy objectives of the NSDP, the plan seeks to provide opportunities, support and protection services for youth and children as valued members of society. It also seeks to prevent and eliminate all forms of violence and discrimination against women, children and vulnerable groups.

1.3.1.3 Policy, Legal, and Administrative Framework of Environmental and Social Consideration

(1) Laws and Regulations related to Environmental Consideration

1) Constitution of the Republic of Vanuatu (1980)

The 1980 Constitution of Vanuatu states that "to protect the Republic of Vanuatu and to safeguard the national wealth, resources and environment in the interests of the present generation and for future generation" is one of the fundamental duties, and therefore, the government has to implement environmental conservation and management.

2) The Environmental Management and Conservation Act No. 12 as amended by The Environmental Protection and Conservation (Amendment) Act No. 28

This act is the umbrella environmental legislation in Vanuatu. The EPCA is administered by the Department of Environmental Protection and Conservation and focuses on four main areas such as i) Administration, ii) Environmental impact assessments, iii) Biodiversity and iv) Bio-prospecting laws and community conservation areas (CCAs).

The Amendment Act makes a number of important changes directly relevant to climate change: Further amendments include enforcement provisions, environmental impact assessment procedures, bio-prospecting processes, and details of what constitutes an

offence.

The Act states that all projects, proposals or development activities that: (a) cause or are likely to cause significant environmental, social and/or custom impacts; or (b) cause impacts are subject to an EIA.

3) Environmental Impact Assessment Regulations

The Regulations establish the procedures for undertaking the environmental assessment of Prescribed Activities. The developer is required to first submit a development consent application following which the Department of Environment Protection and Conservation (DEPC) will conduct a Preliminary Environment Assessment (PEA). Implement procedure of PEA and EIA is stated in regulation.

Vanuatu currently does not have emission or water quality standards. Where the environmental standards are not provided in the Regulations, the DEPC requires World Health Organization (WHO) standards to be used. The Regulations do provide guidelines for licenses to discharge waste or emissions but without defined standards the enforcement of these would appear to be difficult.

4) Pollution (Control) Act No.10 of 2013

The Pollution (Control) Act is designed to control the discharge and emissions of pollution by persons directly or indirectly, of substances or things into the environment which may result in harm to the environment and hazardous to human health. Substantial additional work is required to prepare the regulation, to add more detail to the legislation, and to strengthen the capacity of the institutions responsible for the effective implementation of the legislation.

5) Water Resource Management Act (2002)

The Water Resources Management Act (2002) provides for the protection, management and use of water resources in Vanuatu. The Act is administered by the Minister of Lands and Natural Resources.

The Act allows for the designation of policies to protect water resources; and provides for water conservation zones to be established. Section 7 of the Act states that ‘a person must apply to the Director for the right to construct, operate or maintain works for any purpose that does not comply with Section 4 or 5, including:

a) any work in or adjacent to any water or any bore; or
b) any work whose purpose is to supply water to any other person.

The Act applies to the Project and an application to the Director will be made for Water Works and Water Use Permits prior to works commencing.

6) Waste Management Act No.24 of 2014

The Waste Management Act is designed to provide for the protection of the environment through encouragement of effective waste services and operations. The Act focuses mainly on solid waste which includes the following: garbage, household refuse, rubbish, scraps, electronic wastes, trade and industrial wastes. By the Act, in solid form or any other matter,

a thing is determined to be waste. The Act does not include human waste except in the form of sludge or any other form intended for final disposal as a waste product.

The Act specifies the roles and responsibilities of the DEPC as a regulator, and the designated waste management operators as operators, which include the Municipalities or Provincial Government Councils. The Act also allows for licensing of private waste operators (either as individual or company) who wish to operate a landfill site or a waste dump or waste facility.

7) Other Law / Regulation

Other laws or regulations are as follows.

Table 1.3-8 Other Laws / Regulations

Law / Regulation	Outline
The Forestry Act [Cap 276] (2001)	The Forestry Act provides for the protection, development and sustainable management of forests and for the regulation of the forestry sector in Vanuatu and covers: i) Forestry sector planning ii) Requirements for commercial forestry operations iii) Protection of the forest environment iv) Reforestation v) Timber export
Quarry Act No.9 of 2013	An Act to provide for the regulation of quarry and for related purposes. A holder of a Quarry Permit granted by the Commissioner of Mines has the right to prospect for and extract building materials, which are defined as “mineral substances and rocks community used for building, road making or agricultural purposes.” The Act has the 4 classes of quarry permits such as a) Commercial permit; b) Landscaping permit; c) Public Works Department permit; and d) Occasional permit. Applications for the quarry permit requires the Contractor to submit a Quarry Management Plan (QMP) and consent from the DEPC (usually assessed based on the content of the QMP) to the Department of Geology, Mines, Minerals and Water Resources (DGMMWR). Once issued, the permit will define the quarry area and the conditions which will also tie into the DEPC consent conditions.
Public Health Act 22 of 1994	The Public Health Act makes general provisions for public health in Vanuatu, including regulation of waste management, sanitation, and prohibiting water pollution. Under the Act, the Ministry of Health retains an important responsibility for many waste management activities. The Ministry acknowledges the need for minimum standards in the areas of Environmental Health: clinical waste, food, water, solid waste management, housing, pollution, and sanitation and port health. The Ministry recognizes that there are special stresses/ problems faced by the urban environment including: collection and disposal of large quantities of rubbish, sub-standard housing, water quality, water supply not keeping up with population growth, unhygienic conditions of food for sale, industrial pollution, and lack of proper drainage system.
Physical Planning Act	The Physical Planning Act provides urban development and planning control for Vanuatu. Under this Act a municipality or local government body may declare any area under its jurisdiction to be a Physical Planning Area. The Physical Planning Act administered by the Ministry of Internal Affairs is responsible for planning both in the rural and urban physical planning areas. The majority of Santo area is administered by the Sanma Provincial Council. The Luganville Municipal Council (LMC) and the Sanma Provincial Council who are responsible for the area proposed for the project ensures that the rules of physical planning are followed. Those parts of Sanma (including Fanafo) which are remote have not been declared Physical Planning Areas and are not subject to planning and building controls.
Control of Nocturnal Noise Act	The Act prohibits excessive noise between 9pm and 5am particularly in the urban areas of Port Vila and Luganville. This is mainly for the urban areas, but where noise is an issue in rural areas, the Act can also be applied. In case nocturnal noise is happened on this project, an application to the Sanma Provincial Council will be needed prior to works.
National Parks Act (1993)	The Act provides for the declaration of a national park or nature reserve, the establishment of a National Parks Committee, and an organizational structure for the protection of national parks. National parks or nature reserves include a) those with unique ecosystems and genetic resources; b) habitats for endangered and scientifically valuable species; c) natural beauty, and d) It has archeological and environmental significance.

(2) Relevant Policies in Vanuatu

1) National Sustainability Development Plan 2016 to 2030

The Priorities and Action Agenda (PAA) 2006-2015 set out the national strategic priorities which includes 'Primary Sector Development (natural resources and the environment). It has now been replaced by the National Sustainability Development Plan (The People' Plan) 2016 to 2030. It takes a three pillar approach to grouping targets. Most notably, the second pillar is for the environment. Under this heading, five policy objectives are identified:

- Food and nutrition security
- Blue-Green economic growth
- Climate and disaster resilience
- Natural resource management
- Ecosystems and biodiversity

These high-level political commitments strengthen department level efforts to pursue positive environmental outcomes. Environmental management is the responsibility of the Department of DEPC, although other departments including the agriculture, forestry and fisheries also have some responsibilities in environmental conservation.

2) Vanuatu National Environment Policy and Implementation Plan 2016-2030

On 31 March 2017, the DEPC launched the Vanuatu National Environment Policy and Implementation Plan 2016-2030 (NEPIP). It is a further illustration of the government's commitment to environmental sustainability both under the legislation and the National Sustainability Development Plan. The policy aims to strengthen the linkages and co-ordination between the various policy sectors, government and private sector bodies operating in the environment. It aims to promote environmentally sound and safe management and conservation of the natural resources and environment of Vanuatu.

3) Vanuatu National Energy Road Map 2016-2030 (updated)

The Updated National Energy Road Map (NERM) 2016 to 2030 aligns to the National Sustainable Development Plan (NSDP) (2016-2030) and integrates an overall policy framework, stating aims, goals and objectives and establishes key policy directives for the Energy Sector, electricity and petroleum. It is a high-level framework with a central goal - "To energize Vanuatu's growth and development through the provision of secure, affordable, widely accessible, high quality, clean energy services for an Educated, Healthy, and Wealthy nation" and thus support the NSDP objectives of sustainable improvements in the quality of life of all Ni-Vanuatu by promoting robust and broad-based economic growth

(3) EIA Framework

1) EIA Process

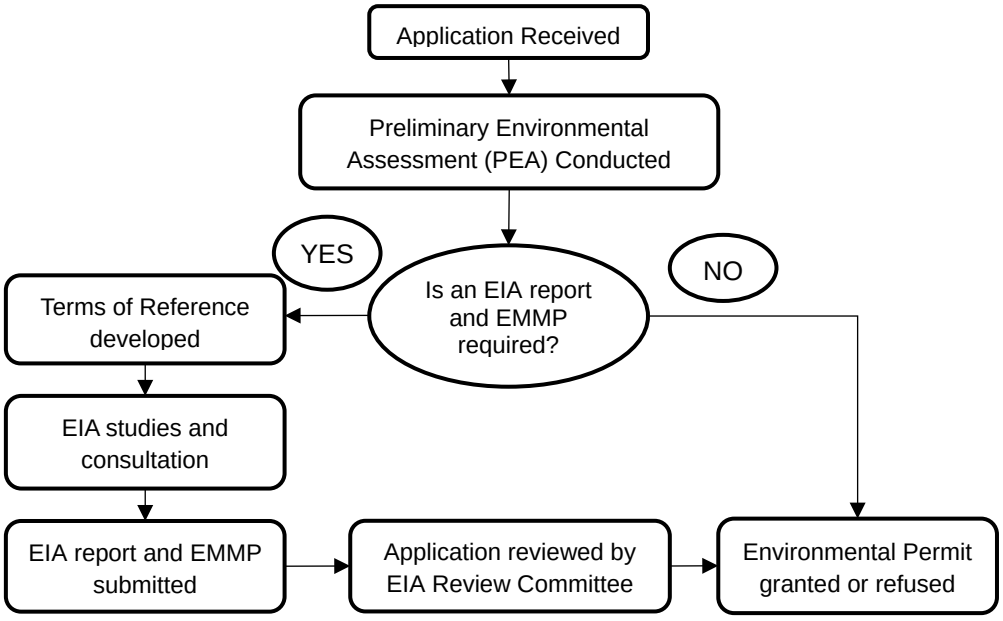
a) EIA Target Project

Under the Environmental Management and Conservation Act (Cap 283), any project, proposal or development that falls within the scope of the Act as follows is subject to the EIA process.

(a) impact or are likely to impact the environment of Vanuatu; and
(b) require any license, permit or approval under any law

b) EIA Process

DEPC will conduct a PEA which determines whether (i) no further assessment is required, (ii) no further assessment is required but an Environmental Management and Monitoring Plan (EMMP), or (iii) where major projects are considered such as logging, large agricultural developments, mining and other Prescribed Activities, an Environmental Impact Assessment (EIA) is required. The DEPC prepare a Terms of Reference (TOR) for the EIA which should include technical, economic, environmental and social investigations. The EIA require public consultation. A Steering Committee reviews the EIA and recommends to the Director of the DEPC for approval, refusal or for more information. The Director can approve a prescribed activity with or without conditions. The process for obtaining EIA approval is shown below.



Source: Guidelines EIA and VIPA (DEPC 2017)

Figure 1.3-3 EIA Process

2) Competent Authorities

DEPC is in charge of environmental governance in Vanuatu. DEPC has 5 departments, namely, Biodiversity and Conservation Division, Environmental Planning and Impact Assessment Division, Provincial Outreach Division, Environmental Protection Division and Finance, Administration and Support Services Division, and Environmental Planning and Impact Assessment Division. These divisions are responsible for the EIA. There is a Sanma environment and Extension officer in Sanma province.

3) Comparison between JICA Guidelines and EIA Related Laws/Regulations in Vanuatu

Comparisons between the JICA Guidelines for Environmental and Social Considerations 2010 (hereinafter referred to as “JICA GL”) and the EIA related laws and regulations in Vanuatu are summarized in the table below.

Table 1.3-9 Comparison between JICA Guidelines and EIA Related Laws/Regulations

No.	JICA Guideline	Related Laws/ Regulations in Vanuatu	Difference	Countermeasures
1	[Complying with laws] The Project must comply with laws, regulations and standards concerning environmental and social considerations established by the governments (central and local governments) where the Project is implemented. Furthermore, the Project must satisfy policies and plans concerning environmental and social considerations established by the governments where the Project is implemented.	[Implementation of PEA and EIA] - Under the Environmental Protection and Conservation Act (EPCA) (2010), all activities or proposed projects that impact or are likely to impact the environment must make an application for approval to the Department of DEPC. - Once an application is lodged and fee paid, the DEPC EIA Unit carry out a PEA and determine whether an EIA is required or not. - An EIA is required for those activities/ projects that cause or are likely to cause significant impacts on “environment, social and/or custom”.	No difference	
2	[Examination of Avoidance and Mitigation Measures] During the implementation of the Project, from its planning stage, the impact on the natural and social environment of the Project must be studied and examined in the early stage as possible. Alternative and mitigation measures to avoid and minimize the impact must be studied and the result must be reflected in the Project plan.	[Examination of avoidance and mitigation measures] The proponent is required to first submit an application containing a description of the proposed activity/ project and identification of likely environmental impacts and required measures to avoid or mitigate the impacts (EIA regulations (2011).	It is not clear whether the result of identification of measures to avoid or mitigate the impacts is reflected in the Project.	It is necessary to ensure that the identified required measures to avoid or mitigate the impacts are reflected in the Project plan.
3	[Examination of alternatives] In order to avoid and minimize the negative impact of the Project and to select the best option from the aspect of environmental and social consideration, several alternatives must be examined.	[Notification of alternatives and mitigation measures] - An EIA report must include a statement of the various alternatives that have been considered for the project, proposal or development activity, including the option of taking no action, and an outline of the reasons for choosing the proposed action. - An EIA report must include a statement of the mitigation action proposed in respect of any adverse impacts identified in the report (EIA regulations (2011).	No difference	
4	[Scope of study and examination] Regarding environmental and social considerations, the impact to be examined includes the impact on human health and security and that on the natural environment (including cross-border and global impact) through air, water, soil, waste, accidents, water use, climate change, ecosystem and fauna and flora. It also includes the impact with respect to social considerations.	[EIA-covered project] - All projects, proposals or development activities that will cause or are likely to cause all or any of the following are subject to the EIA provisions: a) affect coastal dynamics or result in coastal erosion; b) result in the pollution of water resources; c) affect any protected, rate, threatened or endangered species, its habitat or nesting grounds; d) result in the contamination of land; e) endanger public health; f) affect important custom resources; g) affect protected or proposed protected areas; h) affect air quality; i) result in the unsustainable use of renewable resources; and j) result in the introduction of foreign organisms and species. (Environmental Protection and Conservation Act)	The environmental standards are not mentioned in EPCA and EIA regulations. Referring to internationally acknowledged guidelines (WHO, IFC, etc.) or standards of advanced countries.	The expected impact shall be compared and examined.

No.	JICA Guideline	Related Laws/ Regulations in Vanuatu	Difference	Countermeasures
5	[Information disclosure and public involvement] As for the Project which is expected to put relatively big impact on the environment, from the early stage when alternatives of the Project are examined, the information should be disclosed. And then, it is necessary that the stakeholders such as local residents are fully consulted and that the result is reflected in the Project.	[Decision-making] - The project proponent must conduct public consultations on the project, proposal or development activity at times and places as determined by the Director and convenient for those likely to take part. - At least one of the public consultation meetings must be held in the close vicinity of the area of the proposed development. - Notices of public consultation meetings must be given by the project proponent in the manner directed by the Director and such notices must inform the public of: a) the locality and the nature of the project, proposal or development activity b) the location and the time of the public consultation meeting - The cost of convening public consultation meetings is to be met by the project proponent (EIA regulations (2011). [Decision-making on EIA] - The project proponent must conduct public consultations on the project, proposal or development activity at times and places as determined by the Director and convenient for those likely to take part. - At least one of the public consultation meetings must be held in the close vicinity of the area of the proposed development. - If a public consultation meeting is held, notice of it must be given by the project proponent in the manner directed by the Director and must inform the public of: a) the locality and the nature of the project, proposal or development activity; b) where copies of the EIA report can be obtained; c) the location and the time of the meeting; and d) time limit as determined by the Director for the submission of comments in writing. - The cost of convening public consultation meetings is to be met by the project proponent (EIA regulations (2011).	It is not clear from which stage of the project public consultations take place. It is not clear whether the result of public consultations is reflected in the project.	Public consultations shall take place from as early stage of the project as possible. The result of the consultations shall be recorded and reflected in the project.
6	[Monitoring] The donor country shall check the monitoring results which are deemed important for a certain period in order to verify whether the host country considers the environmental and social impact. Information necessary for verifying the monitoring results shall be reported by the host country via a proper manner such as documentation etc.	[Monitoring System] - An environmental management and monitoring plan (EMMP) for a project, proposal or development activity must be submitted with the EIA report. - An EMMP must: a) describe the environmental protection measures that will be put in place by the proponent; b) include and environmental monitoring and surveillance program of action; and c) provide for an environmental monitoring manager to be appointed by the project proponent to verify that the EMMP and protection measures are being fulfilled and adverse impacts are documented. (EIA regulations (2011)	It is not clear whether the result of monitoring is documented in a proper manner.	The result of monitoring shall be documented and submitted to relevant agencies.

1.3.1.4 Alternative Analysis including No Project (No Action)

(1) No Project

The existing hydropower plant (1,200 kW) has been providing a stable power supply as the main power source in Santo Island, however, peak demand of daytime power reached to 1,932kW in 2016 and power demand is being met by diesel power generation which relies on imported fuel. In addition, the average peak power demand growth in Santo Island from 2008 to 2017 was 3.3%, and the demand is expected to increase in the future.

Vanuatu government has stated the following in the "Updated National Energy Road Map (NERM) 2016-2030 " to energize Vanuatu's growth and development through the provision of secure, affordable, widely accessible, high quality, clean energy services for an Educated, Healthy, and Wealthy nation", and the plan to increase the Sarakata River hydropower in Santo Island is a priority issue as an action plan.

If this project is not implemented (zero project), diesel power generation will be operated to meet the ever-growing power demand, and will continue to run counter to the national energy policy. Thus, this project is an essential project for the Vanuatu government. There is possibility to develop solar power generation and wind power generation as a clean energy. However, solar power generation requires a wide area of land, wind power generation costs a lot of initial cost, and the feasibility study must be conducted since both generating conditions are limited so that these are not realistic, and the relevance of implementing this project is high.

(2) Comparison by the Layout Plan

Preliminary Survey of this Project conducted in 2017, "Data Collection Survey on Power Sector in Espiritu Santo in Republic of Vanuatu" proposed 800 kW scale hydropower facility project. In this Survey Project, alternatives to increase hydropower generation capacity were proposed by increasing gross head of the Project based on site surveys and topographic survey.

Table 1.3-10 Comparison of the alternatives to increase Generation Capacity

Items	Preliminary Survey (1)	This Project	
		Alternative – 1 (2)	Alternative – 2 (3)
Elevation of Intake Weir	64.1 masl.	64.2 masl.	82.0 masl.
Elevation of Powerhouse	42.3 masl.	46.2 masl.	46.7 masl.
Gross Head	21.9 m	18.1 m	35.2 m
Generation Capacity	800kW scale	Less than 800kW	1,000kW scale
Layout plan	The planned location of the powerhouse is set downstream of the confluence of the tributaries	Compared to (1), the location of the powerhouse is set to about 100m upstream of the confluence of the tributaries	Compared to (2), The location of the intake weir is set to about 500m upstream
Workability	△ Construction of the powerhouse and headrace conduit will be performed across tributaries (valley topography)	○ Compared to (1), the construction of the powerhouse and the headrace conduit will not be performed across tributaries	○ Compared to (2), the workability of the intake weir does not change significantly
Environment	△ Due to above workability, there is a concern about the outflow of muddy water during the construction.	○ Compared to (1), there is little concern about muddy water during the construction	○ Compared to (2), the construction scope expands slightly, but there is no significant difference in environmental impact
Social	△ Construction cost will be increased due to the ensuring construction safety and environmental measures across tributaries	△ Compared to (1), construction cost is smaller, but power generation capacity is small, which will not contribute to social infrastructure	○ Compared to (2), construction cost will be higher, but there will not be a large impact on the overall construction cost, and power generation capacity will be secured, which will contribute to social infrastructure.

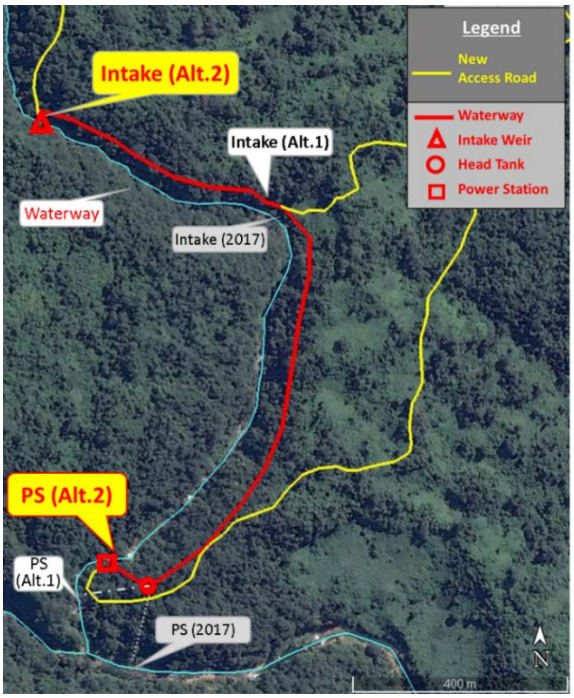


Figure 1.3-4 Comparison of Alternatives

1.3.1.5 Scoping

Under the Vanuatu EIA Procedures, DEPC developed the ToR for EIA after their visit to the project site and discussing with organizations and persons concerned. Based on the result of DEPC's scoping and JICA guidelines, the scoping result was prepared as below.

Table 1.3-11 Result of the Scoping

Items		Evaluation		Reason
		Before/ During Construction	Operation	
Pollution measures				
(1)	Air pollution	B-	D	**[Before/During Construction]** Ambient air quality will be affected by the dust and emission gas generated during the preparation and construction work, but its impact will be limited due to the limited number of heavy vehicles and trucks. **[Operation]** Generation of dust and emission gas is not expected during the operation phase of the hydropower facilities.
(2)	Water pollution	B-	D	**[Construction]** Excavation/embankment work within/along the river and the construction work of intake basin could worsen river water quality during the construction period. Rainfall during or just after above work could cause turbid water. **[Operation]** Generation of the water pollution and turbid water is not expected during the operation phase of the hydropower facilities.
(3)	Waste	B-	D	**[Construction]** Construction waste such as excavated soil, concrete debris, organic waste and soil including organic waste will be generated. And, general waste would be generated from construction workers but the problems caused by it would be very limited. **[Operation]** No work will generate the general waste.
(4)	Soil Pollution	D	D	None of works will cause soil pollution.
(5)	Noise and Vibrations	B-	D	**[Construction]** Construction work by heavy vehicles and trucks will cause problems of noise and vibrations. **[Operation]** Noise and Vibration of generator will be limited, as the generator will be installed in - house.
(6)	Ground subsidence	C	D	**[Construction]** No construction work could cause ground subsidence but it is necessary to check based on the result of the ground survey. **[Operation]** There are no elements to cause ground subsidence.
(7)	Offensive odors	D	D	None of the works will cause offensive odor.
(8)	Bottom sediment	B-	D	**[Construction]** Excavation work on the riverbed would have negative impacts on bottom sediment. **[Operation]** Negative impacts are not expected.
Natural environment				
(9)	Protection area	C	C	No national park or conservation areas inside the project area are identified. The EIA survey will check whether there are any protected areas inside the project area.
(10)	Ecosystems	B-	C	**[Before/During Construction]** Excavation work, conduit work and construction of access road would have negative impacts to plants and animals inside the project area. Need to collect the data on fauna and flora in and around the project site. **[Operation]** EIA survey will check that impact caused by the operation of the hydropower facilities.
(11)	Hydrology	B-	C	**[Construction]** Temporally damming and excavation of the riverbed could have impact on the hydrology of the downstream. **[Operation]** Decreasing of water flow volume between intake and hydropower house is expected by the withdrawing of water for power generation, and its impact will be checked in the EIA survey.
(12)	Geographical features	B-	D	**[Construction]** Geographical impacts by the earth works of headrace conduits and access road construction would be expected. **[Operation]** Negative impacts are not expected.

Items		Evaluation		Reason
		Before/ During Construction	Operation	
Social environment				
(13)	Land acquisition and resettlement	B-	D	**[Pre-construction]** No households need to be resettled, but a certain area of land is needed to be permanently acquired or temporarily used. And, Compensation and support for land, structures, trees and crops would be estimated and implemented during the preconstruction.
(14)	Vulnerable groups/ Poor people	C	D	No vulnerable groups /poor people are identified inside/around the project area, but the EIA survey will check the existence.
(15)	Local economies	B+/-	D	**[Construction]** The project will bring about some benefits such as job creation and economic opportunities to sell foods/goods to workers, while a part of farmland/plantation will lose that area. **[Operation]** Compensation for the farmland/plantation would be done.
(16)	Land use	B-	D	**[Construction]** A part of farmland/plantation cannot temporarily or permanently be used by the construction of access road. **[Operation]** Compensation for the farmland/plantation would be done
(17)	Water use	C	D	**[Construction]** The construction work could worsen water quality and this would be problems of water use for both domestic and farming water purposes if water use is identified inside/around the project area. **[Operation]** Negative impacts are not expected.
(18)	Existing social infrastructures and Services	B-	B+	**[Construction]** The wiring connection between the new cable and the existing cable will cause a problem such as power failure. **[Operation]** After the operation, hydropower facilities will contribute to stable power supply in Santo Island.
(19)	Misdistribution of benefits and damages/ Local conflicts of interest	C	D	**[Pre-Construction]** The project may cause gaps among project affected households if there are affected people inside/around the project area. **[Operation]** Power supply will have positive impact to the whole area in Santo Island and not cause gaps.
(20)	Cultural heritage	C	D	No local archeological, historical, cultural, and religious heritages are identified inside/around the project area, but the EIA survey will check the existence.
(21)	Landscape	D	D	Negative impacts are not expected for the landscape because no tourist resources and no place to attract attention are around the site.
(22)	Gender/ Children's rights	C	D	**[Operation]** There may be a gender bias against the employment of construction workers. **[Operation]** The project is not expected to affect the gender/children's right related issues.
(23)	Infectious diseases such as HIV/AIDS	C	D	**[Construction]** Construction workers are planned to be employed locally, so the infectious diseases such as HIV/AIDS are not expected to be increased. **[Operation]** The negative impacts are not expected.
(24)	Working conditions (work safety)	B-	D	**[Construction]** There would be accidents, injuries and health problems at the construction sites. **[Operation]** Problems related to working safety are not expected.
Others				
(25)	Accidents	B-	D	**[Construction]** There would be traffic accidents, involving local people, during the construction work. **[Operation]** Accidents are not expected.
(26)	Global warming	B-	B+	**[Construction]** A limited amount of greenhouse gas (GHG) will be emitted by the construction. **[Operation]** Amount of the fossil fuel used and generation of GHG will be reduced by the shift of power generation method.

Rating: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected

1.3.1.6 ToR of the Environmental and Social Consideration Survey

Based on the ToR made by DEPC and the result of scoping, the ToR of the Environmental and Social Consideration Survey was prepared as follows.

Table 1.3-12 ToR of the Environmental and Social Consideration Survey

Items of Impact	Survey Items	Survey method
1. Air pollution	(1) Environmental standard, current situations of ambient air (2) Impact of construction work	(1) Literature survey (environmental standard, measuring method) (2) Project components, construction method, construction schedule, heavy vehicles/trucks, construction area, and so on (from JICA Study Team)
2. Water pollution	(1) Environmental standard, current situations of water quality (2) Impact of construction work	(1) Literature survey (environmental standard, measuring method, monitoring data) (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team) (3) Baseline data survey (4) Result of soil and ground survey (from JICA Study Team)
3. Waste	(1) Laws and regulations (2) Impact of construction work	(1) Literature survey (Solid management systems in Vanuatu) (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team)
4. Noise and vibrations	(1) Environmental standard, current situations of ambient noise (2) Impact of construction work	(1) Literature survey (environmental standard, measuring method) (2) Project components, construction method, construction schedule, heavy vehicles/trucks, construction area, and so on (from JICA Study Team) (3) Baseline data survey
5. Bottom sediment	(1) Environmental standard, current situations of bottom sediment (2) Impact of construction work	(1) Literature survey (environmental standard, measuring method, monitoring data) (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team)
6. Ecosystems	(1) Data on fauna and flora (in particular endangered species) (2) Impact of construction work	(1) Literature survey (reports on fauna and flora around the river) (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team) (3) Baseline data survey
7. Hydrology	(1) Current situations (2) Impact of construction work	(1) Literature survey (reports of similar projects) (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team) (3) Result of soil and ground survey (from JICA Study Team)
8. Geographical features	(1) Current situations (2) Impact of construction work	(1) Literature survey (reports of similar projects) (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team) (3) Result of soil and ground survey (from JICA Study Team)
9. Land acquisition / resettlement	(1) Legal framework related to resettlement (2) Households needed to be resettled (3) Compensation policies	(1) Literature survey (legal framework, reports of other projects) (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team) (3) Socio-economic survey, Inventory survey, consultation meetings
10. Vulnerable groups	(1) Current situations	(1) Literature survey (2) Socio-economic survey and consultation meetings

Items of Impact	Survey Items	Survey method
11. Local economy such as employment and livelihood	(1) Impact of construction work	(1) Literature survey (2) Socio-economic survey (3) Consultation meetings
12. Utilization of land and local resources	(1) Impact of construction work	(1) Literature survey (2) Socio-economic survey (3) Consultation meetings
13. Water use	(1) Impact of construction work (during and after the construction work)	(1) Literature survey (2) Socio-economic survey (3) Consultation meetings
14. Existing social infrastructures and services	(1) Impact of construction work	(1) Literature survey (EIA reports of other projects) (2) Consultation meetings (3) Site inspections
15. Misdistribution of benefits and damages	(1) Impact of construction work	(1) Literature survey (2) Socio-economic survey (3) Consultation meetings
16. Cultural heritage	(1) Impact of construction work	(1) Literature survey (2) Consultation meetings (3) Socio-economic survey
17. Landscape	(1) Impact of construction work	(1) Literature survey (2) Consultation meetings
18. Gender/ Children's right	(1) Impact of construction work	(1) Literature survey (2) Socio-economic survey (3) Consultation meetings
19. Infectious diseases such as HIV/AIDS	(1) Impact of construction work	(1) Literature survey (2) Interview survey with organizations concerned
20. Work Conditions	(1) Impact of construction work	(1) Literature survey (2) Interview survey with organizations concerned (3) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team)
21. Accidents	(1) Impact of construction work	(1) Literature survey (2) Interview survey with organizations concerned
22. Global warming	(1) Impact of construction work	(1) Literature survey (2) Project components, construction method, construction schedule, construction area, and so on (from JICA Study Team)

1.3.1.7 Result of Environmental and Social Consideration Survey including prediction result

(1) Air Pollution

The air quality around the project site is great, due to the absence of industries and a very little vehicle usage. There are no air quality or emission standards in Vanuatu.

- Dust: Dust brown up is not seen since ground in the project site is covered by grasses.
- Exhaust gas: Air pollution by the exhaust gas is not seen since only few cars passes at the project site


Photo 1.3-3 Air condition at the project site

1) Construction Phase

Impacts of exhaust gas emission by heavy equipment and construction trucks and dust generated by excavation/embankment works are expected. These impacts are limited and temporary due to the small limited number of trucks and operation days, and the absence of house and building inside the project area. The following countermeasures could mitigate the above problems.

- Using trucks and heavy vehicles, which are in good condition with certificates and conducting regular checks/inspections and maintenance for these vehicles
- Implementing regular sprinkling at the construction site and stock yard, and washing the tires of trucks
- Covering the construction materials loaded on the back of the dump trucks

2) Operation Phase

Generation of dust and exhaust gas by the operation of hydropower facilities are not expected, and only maintenance vehicles will pass the road inside the project site.

(2) Water Pollution

The project site is located at the downstream of the existing hydropower facilities along the Sarakata River and water quality at the upstream and downstream is good.

- Transparency: approx. 1m depth
- Odor: None

Photo 1.3-4 Water condition at the Sarakata river

Water quality at the Sarakata River downstream of the project site by the Department of Water Resources is shown below.

Table 1.3-13 Water Quality at the Sarakata river

Dissolved Oxygen (mg/L)	pH	Temp (°C)	Turbidity (NTU)
21.9	7.9~8.1	24.5~27.5	0.1~2.8

Source: Department of Water Resources

Figure 1.3-5 Water Quality Sampling Point

1) Construction Phase

The impact on water quality is expected mainly due to soil runoff during earth works, concrete leaks during concrete casting, oil leaks from construction equipment and vehicles, and sewage discharge from the site offices. Further, there is a possibility that sediment runoff due to rain during or after the earth works and turbid water after sprinkling and tire

washing may flow into the river and worsen water quality.

Since there are no standard of water quality (drainage) in Vanuatu, it is assumed that the turbidity or SS (Suspended solids) of construction drainage will be controlled during construction phase with reference to Japanese standards as a target value. There is no existing data of SS on the Sarakata River, but the SS value is predicted using the existing data of turbidity by the case of the general correlation between turbidity and SS in Japan.

[Reference] Example of correlation between turbidity and SS in Japan
There are cases where turbidity and SS show the following correlation.
- SS (mg / L) = 0.832 x Turbidity (NTU) + 28.018
- SS (mg / L) = 0.317 x Turbidity (NTU) + 3.469

Reference: Ministry of Land, Infrastructure, Transport and Tourisms, Japan

From the maximum turbidity value of 2.8 NTU in Table 1.3-13, SS can be predicted to be 4.4 to 30.3 mg / L, which is below the minimum effluent standards value in Japan (200 mg / L, daily average 150 mg / L). Therefore, turbid water will be managed so as not to exceed the Japanese standards.

Sarakata river water within at least 2 km from the downstream of the project site is not used, but the following countermeasures of water pollution prevention is important since the river eventually reaches Luganville.

- Earth works at the riverbed will be conducted only during the dry season as much as possible.
- Excavation works on the river bed and construction of intake will be conducted using temporary cofferdam method, with gabions or sandbags etc.
- A sedimentation drainage will be installed in order to treat sediments and to manage turbidity.

2) Operation Phase

Water pollution due to the operation of hydropower facilities is not expected because of flow type hydropower facilities. Regular inspection will be conducted to avoid grease leaks from generator.

(3) Waste

There is no organized waste management system in any rural areas of Vanuatu. Waste generated in the project site will be collected and disposed at Chapius waste disposal site in Luganville.

1) Construction Phase

The organic waste and soils mixed with organic waste will be generated during the site-clearance work. During the construction work, excavated soil will be generated, while general waste will be generated at the site office and construction site. The following countermeasures could mitigate the above problems.

- Organic waste and soil mixed with organic waste, which is generated during the site clearance work, will be disposed of at the waste disposal site in Luganville.

- Garbage containers and temporary toilets will be installed
- Excavated soil will be used for embankment work where possible, and the residual soil will be brought to the temporary soil yard and managed carefully.
- Reuse of residual soil will be considered for use in other public works etc. by DOE.

2) Operation Phase

Waste generated in the operation phase at the management office will only be general waste and the general waste management is expected to not have any impact.

(4) Noise and Vibration

The project site is located in areas where there are no settlements and commercial activities, therefore the increase in noise and vibration caused by the project will be a trivial issue.

1) Construction Phase

Any noise and vibration generated by the operation of heavy machine and construction trucks will be temporary and intermittent, due to the limited construction period. Construction noise and vibration are attenuated quickly with distance, and it is expected to slightly impact the people around the project site. The following countermeasure will be taken.

- Information on the construction work should be provided beforehand to the local residents around the project site, and louder construction works will be restricted to daytime.
- Heavy machines and vehicles with low noise level will be used and its condition will be checked regularly.
- Simultaneous operation of multiple loud machines should be avoided as much as possible.
- The level of noise and vibrations will be regularly measured during the construction phase.

2) Operation Phase

Generator which may generate noise and vibration will be located inside a building, therefore it is expected to have no impact around the project site.

(5) Ground subsidence

As a result of the geological survey, the ground for the facilities' base has been confirmed, therefore it is expected that there will be no impact due to ground subsidence.

(6) Bottom sediment

Current condition of the bottom sediment is as follows.

- Odor: None
- Color: Gray
- Appearance: Sand, gravel, conglomerate


Photo 1.3-5 Bottom sediment condition at the Sarakata river

1) Construction Phase

Excavation/embankment work on the intake construction at the river could affect the bottom sediment. However, its impact is limited because excavation of the bottom sediment is not expected. The following countermeasure will be taken.

- Earth works at the riverbed will be restricted to the dry season as much as possible.
- Construction area will be limited, and temporary cofferdam method using gabions or sandbags etc. will be applied to limit the impacted area.

2) Operation Phase

Impact to the bottom sediment is not expected due to the flow type hydropower facilities.

(7) Protection Area

Protection area is not identified inside / around the project area.

(8) Ecosystem

Current condition of ecosystem is mentioned in the section of Section 1.3.1.2, and evaluation and mitigation measures are as follows.

1) Construction Phase

The area of trees felling by the construction will be approximately 96,000 m^2, and the total number of felled trees is assumed to be 9,600 (1 tree / 10 m^2). Secondary shrub forest is dominant due to human activities and cyclone around the project site, therefore, it is expected that there will be no big impact on the ecosystem. Vulnerable species were identified but its impact will be limited by implementing mitigation measures. Although migratory species were also identified, many of them are found all over the Vanuatu, and impact of the project to their habitat is limited. The following countermeasures will be taken to avoid the worsening of the ecosystem.

- Attention will be paid to wildlife at the time of site clearance and the loss of vegetation should be restricted within the construction area
- Regarding vulnerable species, confirmation work will be conducted during the preparatory work for its existence at the work area, and if it is confirmed,

countermeasures will be taken (relocation of habitat, etc.) in accordance with the instructions of the DEPC. In addition, the habitat will be checked continuously to monitor the existence of habitats.

- Construction work at the riverbed will restricted to the dry season as much as possible
- Minimize the extent of earth work and the extent of tree felling.
- Temporarily used farmland plots must be returned after rehabilitation.

2) Operation Phase

Impact to the ecosystem by the operation of hydropower facilities is not expected since no upstream aquatic life have been identified.

(9) Hydrology

There are no buildings and use of water along Sarakata River between intake and powerhouse, therefore, there is no significant impact caused by the change of hydrology.

1) Construction Phase

As a countermeasure to the impact on hydrology, due to the temporary damming of the river and riverbed excavation during the construction of intake facilities, the following will be carried out.

- Construction work at the riverbed will restricted to the dry season as much as possible
- Appropriate drainage plan will be formulated beforehand.

2) Operation Phase

Decreasing the water flow for generation between the intake weir and the power plant is expected to affect the hydrology. However, its impact is limited since amount of intake will satisfy the maintenance flow amount, and the intake section is limited. The following measures will be taken.

- An appropriate water intake plan will be developed and implemented.
- Management of water intake amount will be done according to the season change.

(10) Geographical features

Large scale earth works will be conducted during the construction of headrace conduit and access road in the project.

1) Construction Phase

The construction of headrace conduit and access road in the steep valley will lead to large-scale excavation, due to slope cutting. The following measures will be taken to avoid the impact on geographical features through this construction.

- Line sharp and width that minimize the amount of earthwork will be planned and constructed within the range that allows to maintain the function of the facility.
- Appropriate slopes and slope measures will be planned and implemented for the excavation and embankments to avoid topographical changes in the future.

2) Operation Phase

Impact to the geographical features by the operation of the hydropower facilities is not expected.

(11) Resettlement and Land acquisition

There will be no involuntary resettlement, but it will be necessary to have permanent and temporary land acquisition, and provide compensation for the agricultural products and trees. The resettlement action plan including the contents of land acquisition, compensation and estimation of the compensation is formulated and implemented properly (refer to Section 1.3.2 Land Acquisition and Resettlement) at the pre-construction phase.

(12) Local economy

During the construction phase, the project would have positive impact on local economies, such as job creation as construction workers and increase in sales of foods to construction workers, while a plantation (PRV) will suffer from loss of farm land partly .The land acquisition plan including contents of the land acquisition, compensation and estimation of the compensation is formulated and implemented properly.

(13) Land Use

During the construction phase, a part of farm land (plantation) cannot be used temporarily. The land acquisition plan including contents of the land acquisition, compensation and estimation of the compensation is formulated and implemented properly.

(14) Water Use

The village of Natoto is the closest to the existing hydropower plant. The people of this village have access to the river for fishing, washing and bathing through a pipe that connects from an existing stand pipe within the boundary of the existing hydropower plant. Since Natoto village is located in an area away from the upstream of the project site, it is expected that there will be no limitations to the use of water for the people. Also for the people in other areas, there are no impacts to water usage by the execution of the project, since the river water is not supplied to other areas around the project site. Impact to the fishing ground at Natoto village is also not expected since water stagnation is not expected due to a run-of-river type power generation.

(15) Existing Social Infrastructures and Services

1) Construction Phase

During the construction phase, the connection work with the existing transmission line will cause a temporary power outage. Informing and explaining the construction information and notifying the affected residents regarding the power outage in advance will be carried out to avoid its impact.

2) Operation Phase

The operation of the new power generation facility will contribute to increase the supply of hydroelectric power, stabilize the electrical infrastructure in Santo Island, and reduce the cost of power generation in comparison to the existing diesel generation.

(16) Misdistribution of Benefits and Damages

There are no affected people in this project. The establishment of power infrastructure through the operation of the hydropower facility will be for all the residents of the entire Santo Island, and there is no benefit or conflict between residents.

(17) Cultural Heritage

Cultural heritage is not identified inside / around the project area.

(18) Gender and Children's right

No negative impacts are expected on gender and children's right due to the project, but it is recommended to check the age at the time of hiring.

(19) Infectious Diseases such as HIV/AIDS

Since construction workers will be recruited locally, the project is not expected to spread infectious diseases such as HIV/AIDS, but it is recommended to mandate workers to undergo HIV prevention training and sign the associated Code of Conduct prior to the commencement of works.

(20) Working Conditions

At the construction site, there would be accidents and injuries, as well as health problems caused by dust and noise. The following measures will be taken in order to mitigate these problems.

- The Work Safety Plan will be prepared, based on the laws and regulations in Vanuatu and the international standards (OHSAS)

- Safety goods will be provided, in addition to arranging regular meetings and trainings, and the necessary measures such as watering will be implemented according to the safety plan.

(21) Accidents

Accidents involving local residents and passenger cars may occur. The following measures will be taken in order to mitigate the expected problems.

- Necessary facilities such as road safety signboard will be installed on the way to the project site near the village.
- Community safety plan will be formulated.
- Construction information will be shared with residents around the project site prior to the construction.
- Traffic management plan will be prepared and trained guards will be assigned, and necessary facilities such as signboards will be installed in order to prevent accidents
- Necessary facilities such as fences will be installed as a project boundary at the site that has a steep slope along the river.

(22) Global Warming

Greenhouse gas (GHG) will be emitted by the construction due to the use of heavy machines

and trucks.

1) Construction Phase

The construction machines, trucks and equipment that are expected to generate GHG are listed along with the amount of CO_2 emission in the below table.

Table 1.3-14 Amount of CO_2 emission by the construction machines

Name	Specificatiion	Unit	Operation time/day	Operation days	Fuel Consumption Rate (L/kW/h)	Output（kW）	Fuel Consumption (kL)	Total Fuel Consumption (kL)	CO2 Emission Unit (t-CO2/kL)	CO2 Emission (ton)
		a	b	c	d	e	f=b x c x d x e	g = a x f	h	i = g x h
Bulldozer	32t with ripper	3	7	687	0.153	238.0	175	525	2.62	1,375.0
Bulldozer	21t	2	7	972	0.153	197.0	205	410	2.62	1,073.8
Vibration roller	0.8～1.1t	5	7	546	0.231	5.0	4	20	2.62	52.4
Tampa	60～80kg	5	7	546	0.346	3.0	4	20	2.32	46.4
Concrete pump truck	Boom type 90～110m3/h	1	7	681	0.078	199.0	74	74	2.62	193.8
Power generator	100kVA	1	7	681	0.145	117.0	81	81	2.62	212.1
Power generator	20kVA	2	7	99	0.145	23.0	2	4	2.62	10.5
Truck crane	16t	1	7	105	0.044	125.0	4	4	2.62	10.5
Motor grader	3.1m	1	7	216	0.108	85.0	14	14	2.62	36.7
Road roller	10～12t	1	7	216	0.118	56.0	10	10	2.62	26.2
Excavator	0.8m3	5	7	999	0.153	104.0	111	555	2.62	1,453.5
Dump truck	10t	5	7	972	0.043	246.0	72	360	2.62	942.8
Agitator truck	4.4m3	1	7	681	0.059	213.0	60	60	2.62	157.1
Tire roller	8～20t	1	7	216	0.085	71.0	9	9	2.62	23.6
Total										5,614

Source: JICA Study Team

The GHG will be generated from trucks, heavy machines and equipment, but the volume of GHG is limited due to the limited number of vehicles/machines and the limited area where these vehicles move. The following measures will be taken in order to mitigate expected impacts.

- Using trucks and heavy vehicles that are in good condition with certificates and conducting regular checks/inspections and maintenance for these vehicles
- Stopping the unnecessary idling of construction vehicles.

2) Operation Phase

Use of fossil fuel and generation of GHG can be reduced by switching the power generation system from diesel power generation to renewable energy. Estimated GHG reduction by the operation of hydropower facilities is approximately 602,280 tons / year (refer Section 3.4.2 for details).

1.3.1.8 Impact Assessment

Result of the impact assessment is shown below.

Table 1.3-15 Result of Impact Assessment

Items		Evaluation during Scoping		Evaluation based on survey result		Reason
		Before/ During Construction	Operation	Before/ During Construction	Operation	
Pollution measures						
(1)	Air pollution	B-	D	B-	D	**[Before/During Construction]** Ambient air quality will be affected by the dust and emission gas generated during the earth works etc., but its impact will be limited due to the limited number of heavy machines and trucks, and limited project area. **[Operation]** Generation of dust and emission gas is not expected by the operation of the hydropower facilities.
(2)	Water pollution	B-	D	B-	D	**[Construction]** Excavation/embankment work within/ along the river and the construction of intake weir could worsen river water quality during the construction period. Rainfall during or just after above work could also cause turbid water. **[Operation]** Generation of the water pollution and turbid water is not expected during the operation phase of the hydropower facilities.
(3)	Waste	B-	D	B-	D	**[Construction]** Construction waste such as excavated soil, concrete debris, organic waste and soil including organic waste will be generated. And, general waste would be generated by the construction workers but its impact would be very limited. **[Operation]** Little general waste will be generated, but it is expected to have no impact.
(4)	Soil Pollution	D	D	D	D	None of the works will cause soil pollution.
(5)	Noise and Vibrations	B-	D	B-	D	[**Construction]** Construction work by heavy machines and trucks will cause noise and vibrations. **[Operation]** Noise and Vibration of generator will be limited since the generator will be installed in the building.
(6)	Ground subsidence	C	D	D	D	Impacts to the ground subsidence is not expected based on the result of the ground survey.
(7)	Offensive odors	D	D	D	D	None of the works will cause offensive odor.
(8)	Bottom sediment	B-	D	B-	D	**[Construction]** Excavation work on the riverbed would have negative impacts on the bottom sediment. **[Operation]** Negative impacts are not expected.
Natural environment						
(9)	Protection area	C	C	D	D	There is no protected area inside/around the project site.
(10)	Ecosystems	B-	C	B-	D	**[During Construction]** Earth works and construction of conduit and access road would have negative impacts on plants and animals inside the project area. **[Operation]** impacts to ecosystems by the operation of the hydropower facilities is not expected.
(11)	Hydrology	B-	C	B-	B-	**[Construction]** Temporarily damming and excavation of the riverbed could have impact on the hydrology of the downstream. **[Operation]**Decreasing of water flow volume between intake and hydropower house is expected by the withdrawing of water but its impact will be limited since amount of intake will be managed.
(12)	Geographical features	B-	D	B-	D	**[Construction]** Geographical impact due to the earth works of headrace conduits and access road construction would be expected. **[Operation]** Negative impacts are not expected.

Items		Evaluation during Scoping		Evaluation based on survey result		Reason
		Before/ During Construction	Operation	Before/ During Construction	Operation	
Social environment						
(13)	Land acquisition and resettlement	B-	D	B-	D	**[Pre-construction]** No household needs to be resettled, but a certain area of land has to be permanently acquired or temporarily used. And, compensation and support for land, structures, trees and crops would be estimated and implemented during the preconstruction.
(14)	Vulnerable groups /Poor people	C	D	D	D	No vulnerable groups /poor people are identified inside/around the project area.
(15)	Local economies	B+/-	D	B+/-	D	**[Construction]** The project will bring about some benefits such as job creation and economic opportunities to sell foods/goods to workers, while a part of the farmland/plantation will be lost. **[Operation]** Compensation for the farmland/plantation would be done.
(16)	Land use	B-	D	B-	D	**[Construction]** A part of farmland/plantation cannot be temporarily or permanently used due to the construction of access road. **[Operation]** Compensation for the farmland/plantation would be done
(17)	Water use	C	D	D	D	Since there is not river water supply around the project site, water use will not be limited.
(18)	Existing social infrastructures and Services	B-	B+	B-	B+	**[Construction]** The wiring connection work to connect the new cable and the existing cable will cause problems such as power failure. **[Operation]** After the operation, hydropower facilities will contribute to stable power supply in Santo Island.
(19)	Misdistribution of benefits and damages/ Local conflicts of interest	C	D	D	D	There are no affected people in the project site, and power supply will have positive impact to the entire Santo Island and will not cause gaps.
(20)	Cultural heritage	C	D	D	D	There is no cultural heritage inside/around the project site.
(21)	Landscape	D	D	D	D	Negative impacts are not expected to the landscape, because there are no tourist resources and places that attract attention around the site.
(22)	Gender/ Children's rights	C	D	D	D	The project is not expected to affect the gender/children's right related issues.
(23)	Infectious diseases such as HIV/AIDS	C	D	D	D	Infectious diseases such as HIV/AIDS are not expected to be increased by the execution the project.
(24)	Working conditions (work safety)	B-	D	B-	D	**[Construction]** Accidents, injuries and health problems may occur at the construction sites, especially along the river side. **[Operation]** Problems related to working safety are not expected.
Others						
(25)	Accidents	B-	D	B-	D	**[Construction]** Traffic accidents, involving local people may occur during the construction work. **[Operation]** Accidents are not expected.
(26)	Global warming	B-	B+	B-	B+	**[Construction]** A limited amount of greenhouse gas (GHG) will be emitted by the construction, but its impacts are limited. **[Operation]** Amount of the fossil fuel used and generation of GHG will be reduced due to the change of power generation method.

Rating: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C: Extent of positive/negative impact is unknown (Examination is needed. Impacts may become clear as study progresses.)
D: No impact is expected

1.3.1.9 Mitigation Measures and Its Cost

Proposed mitigation measures and the cost to implement these measures are summarized below.

Table 1.3-16 Mitigation Measures against Expected Concerns and Cost

No	Items	Proposed Mitigation Measures	Implementing agency	Responsible organization	Cost (USD)
Pre-construction phase					
13	Resettlement/ Land acquisition	• Land acquisition, arrangement of compensation, and supporting measures based on Land Acquisition Plan (LAP)	DOE	DOE, DOL	LAP cost
15	Local economy				
16	Land use				
Construction phase					
1	Air pollution	• Trucks and heavy machines under good conditions with certificates are used and regular checks/ inspections and maintenance are conducted for these vehicles • Regular sampling at the construction site and washing of tire trucks are done • No idling of all vehicles	Contractor	DEPC/DOE	Included in construction cost
26	Global warming				
2	Water pollution	• Earth works at the riverbed will be conducted during the dry season • Temporary cofferdam method will be used at the time of excavation works on the riverbed and during the construction of intake facility • Countermeasures for the sediment and turbidity will be carried out and they will be managed	Contractor	DEPC/DOE	Included in construction cost
3	Waste	• Organic waste and soils mixed with organic waste will be disposed of at the disposal site. • Excavated soils will be used for embankment work and the residual soil will be brought to the temporary soil yard and managed adequately.	Contractor	DEPC/DOE	Included in construction cost
5	Noise and Vibration	• Information on the construction work should be provided beforehand to the local residents, and the louder construction works will be restricted to daytime. • Heavy machines and vehicles with low noise level will be used and its condition will be checked regularly. • Simultaneous operation of multiple noisy machines should be avoided as much as possible. • The level of noise and vibrations will be regularly measured.	Contractor	DEPC/DOE	Included in construction cost
8	Bottom sediment	• Earth works at the riverbed will be restricted to the dry season. • Construction area will be limited and temporary cofferdam method will be executed.	Contractor	DEPC/DOE	Included in construction cost
10	Ecosystems	• Attention will be given to wildlife at the time of site clearance and the loss of vegetation should be restricted within the construction area • Confirmation of the existence of vulnerable species and continuous monitoring • Construction work at the riverbed will restricted to the dry season as much as possible • Temporary used farmland plots must be returned after rehabilitation.	Contractor	DEPC/DOE	Included in construction cost
11	Hydrology	• Construction work at the riverbed will restricted to the dry season • Appropriate drainage plan will be formulated beforehand.	Contractor	DEPC/DOE	Included in construction cost

No	Items	Proposed Mitigation Measures	Implementing agency	Responsible organization	Cost (USD)
12	Geographical features	• Line sharp and width that minimize the amount of earthwork will be planned and constructed. • Appropriate slopes and slope measures will be designed and implemented for the excavation and embankments.	Contractor	DOE	Included in construction cost
15	Local economy	• Employ local people as construction workers	Contractor	-	Included in construction cost
19	Existing Social Infrastructures and Services	• Informing and explaining the construction details and the notifying the affected residents about power outage will be carried out	Contractor / DOE	DOE	Included in construction cost
26	Working Conditions	• The Work Safety Plan will be prepared, based on the laws and regulations in Vanuatu and international standards • Safety goods will be provided, in addition to the regular meetings and trainings, and necessary measures such as watering will be implemented according to the safety plan.	Contractor	DOE	Included in construction cost
29	Accidents	• Necessary facilities such as road safety signboard will be installed on the way to the project site. • Community safety plan will be formulated. • Construction information will be shared with residents prior to the construction. • Traffic management plan will be prepared and trained guards will be assigned. • Necessary facilities such as fences will be installed as project boundary at the site	Contractor	DOE, Police Force/ Local authority	Included in construction cost
Operation phase					
11	Hydrology	• An appropriate water intake plan will be developed and implemented. • Management of water intake amount will be done according to the season change.	DOE	DOE	-

1.3.1.10 Environmental Management and Monitoring Plan

The following Environmental and Monitoring Plan will be implemented in order to monitor the implementations of planned mitigation measures during pre-construction, construction and operation phase.

Table 1.3-17 Environmental Management and Monitoring Plan (EMMP)

Environmental items	Monitoring item	Parameter/Indicator	Location	Frequency	Responsible	Budget
Pre-construction						
Land acquisition, compensation payment and other support	Compensation for land and other assets	- Area of land acquisition and lease - Number of assets	Project area	Once before construction	DOE	LAP monitoring
	Complaints resolutions	GRM log book	Project area	Time of complaints happen	DOE	LAP monitoring
Construction phase						
Accident and incident	Complaint (in general such as noise, traffic jam, and accidents)	Records of complaints	Project area	Time of complaints happen	Contractor DOE	Construction cost
Air Pollution	Equipment and automobiles in good shape	Regular inspection and maintenance (daily check sheet/work report)	Project area	Daily	Contractor	No cost applicable to monitor.

Environmental items	Monitoring item	Parameter/Indicator	Location	Frequency	Responsible	Budget
	Air quality	Level of dust (visual observation)	Project area	Daily	Contractor	Construction cost
	Mitigation measures such as sprinkling water, washing tires	Records on water sprinkling/ washing (check sheet/work report)	Project area	Daily	Contractor	Construction cost
Air pollution/ noise & vibrations	Equipment and automobiles with less emission gas and noise	Number of Automobiles with certification on site		As appropriate	Contractor	No cost applicable to monitor.
Water pollution	Surface water quality	Turbidity or Suspended Substance (SS) (by portable water quality meter) oil & grease (observation)	Discharge point / Upper site/ lower site of Sarakata river	Weekly	Contractor	Construction cost
	Condition of turbidity measures work	Condition of function and damage (visual inspection)	Project area	Daily	Contractor	Construction cost
Waste	Management of excavated soil, concrete debris and others	Proper storage nor not (check sheet/work report) Reuse or not (check sheet/ work report)	Project area	Monthly	Contractor	Construction cost
	Management of general waste	Records of waste disposal	Project area	Monthly	Contractor	Construction cost
Bottom sediment/ Ecosystem	Mitigation measures	Mitigation measures are done or not (check sheet/ work report)	Project area	Weekly	Contractor	Construction cost
Hydrology	Condition of steep slope	Condition of steep slope along river (visual inspection)	Project area	Weekly	Contractor	Construction cost
Work conditions	Occupational Safety and Health plan	Availability of OHS Plan	Project area	Monthly	Contractor	Construction cost
	Meetings and trainings	Number of meetings and trainings				
	Safety goods for workers	Number of workers with safety gear				
	Occurrence of accidents and injuries	Records of accident and injuries				
Accident/ Traffic congestions	Traffic management Plan	Availability of TMP	Project area	Monthly	Contractor	Construction cost
	Implementation of TMP	Availability of guard, signboard, and so on (activity records)	Project area	Monthly	Contractor	Construction cost
Operation phase						
Hydrology	River channel	River channel is changed or not	Between intake weir and hydropower house	Twice a year (Dry & Wet season)	DOE	Operational cost

1.3.1.11 Stakeholder Meetings

Stakeholder meetings regarding environmental and social consideration were be held as follows. The details of the meeting are shared with local land owners and relevant agencies to confirm the translucency of the project and to hold the meetings as necessary according to the progress of the project in the first and second meetings. The outline of environmental and social survey was also explained during the third meeting. Record of meeting is attached in Appendix.

Table 1.3-18 Outline of the stakeholder meetings

No.	Date	Venue	Main topics
1	20 November 2018	Sanma Province Chamber,	Explanation of project and agreement of site survey
2	5 December 2018	Sanma Province Chamber,	Explanation of site survey progress and confirmation of land issue
3	17 June 2019	Natoto village	Explanation of environmental and social survey
4	16 December 2020	Sanma Province Chamber,	Explanation of the project outlines and results of the environmental and social survey and confirmation of acceptance of the project.

(1) 1st and 2nd Meetings

The details of the meeting are shared with local land owners and relevant agencies to confirm translucency of the project and to hold the meetings as necessary according to the progress of the project in the first and second meetings. Outline of the meetings is as follows.

Table 1.3-19 Outline of the 1st and 2nd meetings

	1st meeting	2nd meeting
Date	20 November 2018	5 December 2018
Venue	Sanma Province Chamber	Sanma Province Chamber
Purpose	- To obtain the understanding through the explanation of the project background - To inform and obtain the agreement regarding site survey	- To share the progress of site survey - To explain the project and the land issue caused by the project
Participants	- Department of Land in Santo, Officers of Sanma province, DOE, VUI - Land owner: 8 representatives	- Department of Land in Santo, Officers of Sanma province, URA, DOE, VUI - Committee members established in the 1st meeting
Output	- Communication framework between land owners and DOE was confirmed - Sarakata Hydro Phase Two Committee was established in order to communicate information related to the project and hire the local workers during the construction phase	- Some roles such as Chairman were selected from Committee

Photo 1.3-6 1st meeting held on 20th November 2018

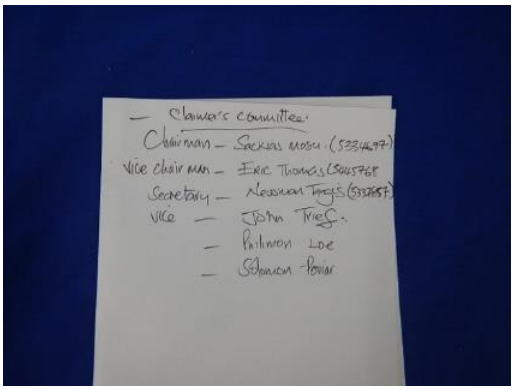


Photo 1.3-7 2nd meeting held on 5th December 2018

(2) 3rd Meeting

3rd stakeholder meeting with landowners and resource users of the area was held at Natoto Village, above the existing hydropower facility. Benefits and problems of the existing hydropower facility were shared, and the participants showed interest and intent to support the project during the meeting. Outline of the 3rd meeting is as follows.

Table 1.3-20 Outline of the 3rd meeting

Date	17 June 2019
Venue	Natoto Village
Participants	16 participants - Local residents: 14 - Consultant: 2
Agenda	- Introduction of the project - Contents of the environmental and social survey - Q&A
Output	- Interesting and intension to support for the project were received - There are no big concern about land use and cultural heritage. - It has been agreed that any information concerning the proposed project must be communicated through the committee established with land owning group

Photo 1.3-8 3rd meeting held on 17th June 2019

(3) 4th Meeting

4th stakeholder meeting with landowners and resource users of the area was held at Natoto Village, above the existing hydropower facility. Benefits and problems of the existing hydropower facility were shared, and the participants showed interest and intent to support the project during the meeting. Outline of the 4th meeting is as follows.

Table 1.3-21 Outline of the 4th meeting

Date	December 16, 2020
Venue	Sanma Province Chamber
Participants	11 participants including local residents, Sanma province, DOL, DEPC and DOE
Agenda	- Explanation of the project outlines - Report of the result of the environmental and social survey - Sharing the land acquisition plan - Q&A
Output	- The contents of the project and the measures for environmental and social considerations were shared with the local residents. - Holding consultations again before the commencement of the construction work and before the operation of the facilities was requested. - There was no objection to the project, and it was agreed to continue sharing information.

Photo 1.3-9 4th meeting held on 16th December 2020

1.3.2 Land Acquisition and Resettlement (Land Acquisition Plan: LAP)

1.3.2.1 Necessity of the Land Acquisition and Resettlement

Construction of the hydropower facilities (1,000 kW), transmission facilities and access road are the project components which affects land acquisition and resettlement. Since there are no affected people in the project site, there is no resettlement, but land acquisition is needed to implement the project. Range of the impacts is shown as follows. Of these, most of the project sites are PRV's plantations (farm land).

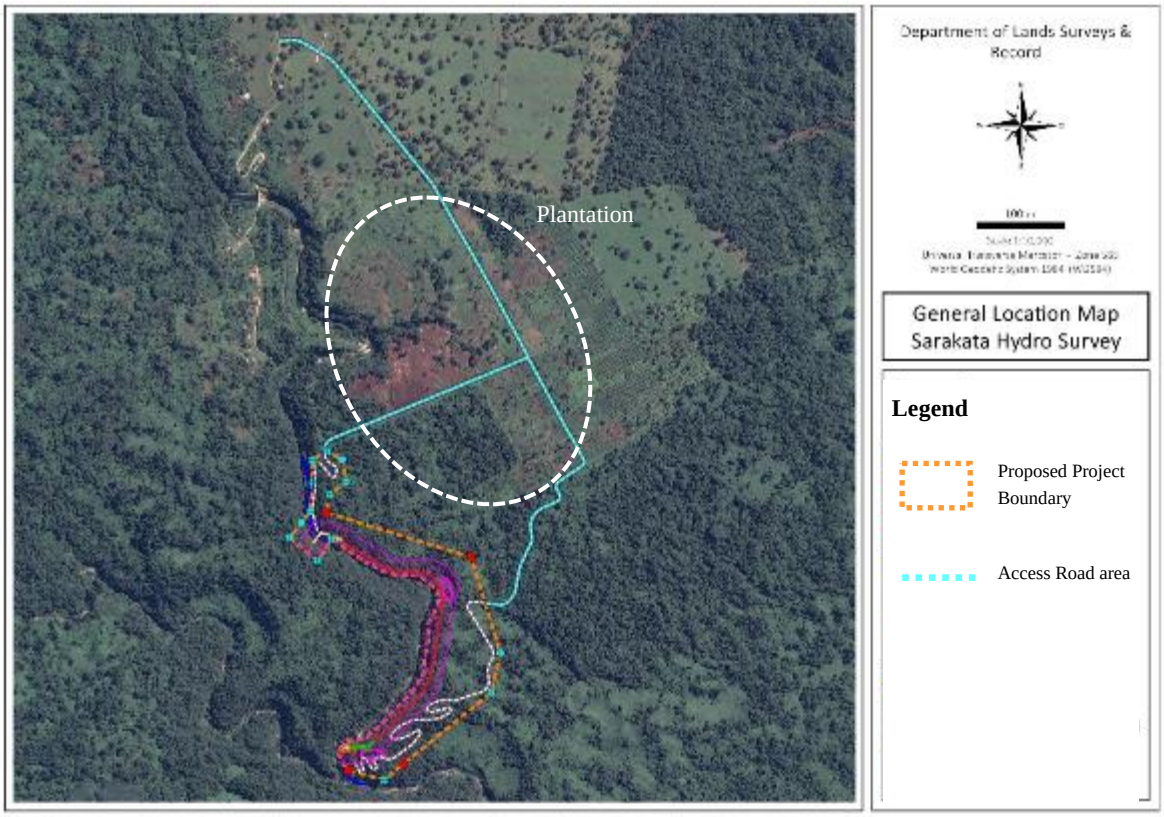


Figure 1.3-6 Range of the impacts to the land acquisition

1.3.2.2 Legal Framework regarding Land Acquisition and Resettlement

(1) Laws and Regulations regarding Land Acquisition and Resettlement

1) Constitution of the Republic of Vanuatu (1980)

Chapter 12 in the Constitution shows description of the lands follows.

- All land in the Republic of Vanuatu belongs to the indigenous custom owners and their descendants.
- Parliament shall prescribe such criteria for the assessment of compensation and the manner of its payment as it deems appropriate to persons whose interests are adversely affected by legislation
- Land transactions between an indigenous citizen and either a non-indigenous citizen or a non-citizen shall only be permitted with the consent of the Government.
- Government may own land acquired by it in the public interest.

2) Land Reform Act (1980)

This Act specifies that all land titles will be customary or transferred to the traditional owners, whose lineage can be traced back locally to 200 years. There are also details specified such as land management plan committee and roles of the negotiator and representative.

3) Land Leases Act (1983)

The Act provides for the creation and disposition of lease land, their registration, mortgages, transfers, transmissions, easements, subdivisions, etc. and all land dealings connected with leases. As with any registration status, the basic position is that leases and other dealings in land only gain their legal effect after the registration, and upon registration the rights of the proprietor are "not liable to be defeated" (i.e., are indefeasible. Following requirement are shown in the Act.

- the requirement that the lessee will not dispose of the leased land or any interest in it "without the previous written consent of the lessor", which consent shall not be unreasonably withheld (Sec. 40A)
- the requirement not to use the land "for any purpose other than that for which it was leased without the previous written consent of the lessor", which consent shall not be unreasonably withheld (Sec. 41(i));
- the requirement that, on determination of the lease, the lessee will deliver up vacant possession of the leased land and any improvements (Sec. 41(j)).

4) Land Acquisition Act (1992)

The Act is the key law directly related to land acquisition and resettlement. This Act gives the MOL full discretionary powers to acquire land on behalf of the Government. It covers details such as to what extent of will the compensation be under the Act:

- Compensation for damages made during the process of land valuation;
- Compensation entitlements for land and for rents and business losses;
- Basic rights for grievance and appeals; and
- Notice periods.

This Act does recognize market value compensation for land, but is very vague in terms of compensation entitlements for rents and businesses.

5) Custom Land Management Act (2013)

This Act strengthens the legal framework concerning title to custom land and concerns management of custom land by customary institutions. It formalizes the recognition of customary institutions termed 'nakamals', which means the meeting at the traditional meeting place, and 'custom area land tribunals' to determine the rules of custom which form the basis of ownership and use of land in Vanuatu.

6) Customary Land Tribunal Act (2001)

As per the title, this Act details the set-up of the Customary Land Tribunal at village, island etc. level, its basic terms of reference (TOR), especially for dispute resolution and process to be followed by the affected persons to appeal the tribunal decision.

7) Valuation of Land Act (2002)

This Act stipulates matters related to the organization of the "Valuer General" Office and their role. The Act does not stipulate minimum approach to valuation of the land, which is more directly specified in the "Land Acquisition Act". Furthermore, this Act is unclear

about the role of the Valuer General office in terms of relocation/involuntary displacement of households as well as valuation of structures, incomes and businesses.

(2) Land Acquisition Process

Land acquisition process in Vanuatu has the following items according to the Land Acquisition Act. This process is managed and implemented by the Ministry of Land and Natural Resources (MOL)

- Intention to acquire land/easement
- Declaration to acquire land/easement
- Assessed Compensation
- Payment and Publishment of the Order

The land acquisition usually needs a period of 6 to 8 months from the application to completion. The period, however, can be shortened according to the degree of project importance or requests to DOL.

1) Intention to acquire land/easement

Request to commence the land acquisition process for the proposed land of the project is sent to MOL, and the MOL determines whether the land is of national interest. Then, MOL and the developer facilitate and coordinate to serve a Public Notice according to Schedule 3 of the Land Acquisition Regulation. This notice is a declaration of MOL Intent to acquire the project land and the easement for national interest purposes, and it must have been obtained within the period of last 30 days. The land owners or lessors can object only if there is no proper process for acquisition or in their view the land is not for public interest. The public notice is also accompanied with a sketched plan of the project land and the easement, which has been prepared by MOL by their survey at the site.

2) Declaration to acquire land/easement

If the MOL is satisfied with the outcome of the first Public Notice (Schedule 3), process for the next stage of acquisition is decided and a second Public Notice is served according to Schedule 4 of the Land Acquisition Regulation. This is to declare that the Government is acquiring the land and creating an easement. This Public Notice must now be supported by the proper approved “Survey Plan” of the land and the easement that the Government is declaring as public land, and the survey plan must be approved by the Surveyor General of the DOL.

3) Assessed Compensation

After accomplishing the above, MOL assesses the proposed land according to following items and determines the compensation cost.

- The market value of the land or easement on the date of the notice of intention to acquire such land or easement;

- The value of damage sustained during investigations, and damage sustained by the owner or any concerned persons due to the loss of any growing crops or trees which may be on the land at the time of notice of intention of acquisition of the land;

- The value of damage sustained by the custom owner or any concerned persons at the time of land acquisition intention notice due to the severing of the land from his other land.

- Where a part of any land is acquired, the value of damage if any sustained by the custom owner or any persons concerned, at the time of land acquisition intention notice due to reason that the acquisition is negatively affecting the remaining part of his land and interest and any subsequent negative effect by virtue of the use to which the acquired land or interest is put;

- If, in consequence of the acquisition of the land, the custom owner or the person interested is compelled to change his residence or place of business, the reasonable expenses, if any, incidental to such change.

After estimating the cost, a third Public Notice (Schedule 5: Assessed compensation) is served. Within 30 days of this third Public Notice, the Lessors and Lessee (with interested parties) will have to determine their own claims for compensation.

4) Payment and Publishment of the Order

After the final Notice, the next step is to inform the interested parties that after all the consultations, the final agreed determination of the compensation of the land have been reached, and the payment of the compensation will be done under the supervision of Ministry of Finance and Economic Management: MFEM.

After payment, the MOL must issue an Order to permit entry into the land and occupy the land, stating that the easement has been acquired and the proposed land is registered.

(3) Related Authorities

The Government has established relevant offices to deal with land issues and in that respect, these are the appropriate offices to channel the land matters and provide assistance where needed. These offices are as follows.

- Ministry of Lands & Natural Resources
- Department of Land
- Valuer General Office
- Customary Land Management Office
- State Law Office

1.3.2.3 Policy of Land Acquisition and Resettlement

(1) JICA's Policy in Resettlement

JICA's Policy in Resettlement includes the following items.

(a) Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

(b) When, after such an examination, avoidance is proved unfeasible, effective measures to minimize impact and to compensate for losses must be agreed upon with the people who will be affected.

(c) People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

(d) Compensation must be based on the full replacement costs as much as possible.

(e) Compensation and other kinds of assistance must be provided prior to displacement.

(f) For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

(g) In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

(h) Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.

(i) Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

(j) Above principles are complemented by World Bank OP 4.12, since it is stated in JICA Guideline that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". Additional key principle based on World Bank OP 4.12 is as follows.

(k) Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

(l) Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

(m) Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

(n) Provide support for the transition period (between displacement and livelihood restoration.

(o) Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

(p) For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

Source: JICA's Guidelines for Environmental and Social Considerations, 2010.

(2) Comparison between JICA's Guidelines and Related Laws in Vanuatu

A comparison and gap analysis of the policies for some key issues between JICA Guidelines and Vanuatu's relevant regulations are as follows.

Table 1.3-22 Comparison between JICA's Guidelines and Related Laws in Vanuatu

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
1	[Avoidance of involuntary resettlement] Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.	No provision.	There is no minimum standard that requires the projects to minimize land acquisition and impacts to the community.	The project shall adopt the objective of minimizing involuntary land acquisition and resettlement impacts to community and business/ productive interests are avoided through careful technical design.
2	[Mitigation measures for displacement] When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	No provision.	There is no minimum standard that requires the projects to minimize land acquisition and impacts to the community.	The project will ensure that all resettlement and land acquisition and impacts to community and business/ productive interests are minimized wherever possible.
3	[Securing livelihood and assistance] People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.	- Compensation is determined based on issues including land type, crops etc. (Land Acquisition Act) - Land is valued by Valuer- General in the MLNR.	Compensation does not include "non-land producing" incomes such as income from shop business etc. Laws and practices in Vanuatu do not recognize the standards of living of the poor and vulnerable, in determining compensation for land acquisition and resettlement. There is no provision to improve or at least restore the livelihood of all DPs.	The LAP includes a provision for restoration for APs under the project.
4	[Valuation based on replacement cost] Compensation must be based on the full replacement cost as much as possible.	- In Vanuatu valuation of land is stipulated by Law, and is conducted based on several factors regarding that specific plot of affected land such as lease and ownership type; location of property; amenities; market price of nearby properties; physical land characteristics; and intangibles. (Land Acquisition Act) - The law specifically points out times for disclosure prior to valuation, time for objection to valuation and acquisition of lands and assets. (Land Acquisition Act) - Land is valued by Valuer General in MLNR. The VG will determine compensation requirements relating to land, land-based income losses. All other compensations (monetary and non-monetary) will be based on replacement at the existing market rates.	The law does not provide any clauses for prompt compensation, income restoration and entitlements.	The LAP includes a provision for restoration for APs under the project.
5	[Compensation prior to displacement] Compensation and other kinds of assistance must be provided prior to displacement.	Compensation is to be provided after the period of disclosure and the period for objection is completed.	Legislation does not clearly state that compensation will be provided prior to the commencement of construction, which force physical/economic displace-ment impacts to occur.	The project will ensure that land acquisition, resettlement and/or compensation measures are completed prior to commencing of construction.
6	[Development and disclosure of Resettlement Action Plan] For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	Under Vanuatu Law, land acquisition and resettlement and compensation are carried out focusing on households affected and the values of the land and structures affected. (Land Acquisition Act)	A LAP per se is not necessarily required.	The project will ensure that a LAP is prepared, and it is updated at the time of detailed design.

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
7	[Holding public consultation meetings] In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	The law, and current practices, does require the land acquisition and relocation orders to be disclosed several times over radio and in the printed media over a 1-month period, as well as display on-site. (ADB reports)	There is no recognition of vulnerable groups nor the consultation with, or participation of APs/ DPs at any part of the process, except in the case of people given opportunity to make objections.	JICA GL will be enforced in that prepared RP and its implementation will require a level of participation and consultation.
8	[Use of local language] When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	A notice for land acquisition is in writing and in Bislama, English and French languages. (Land Acquisition Act)	Only the radio would be useful for the illiterate to become informed of any pending land acquisition and resettlement activity on a specific site.	The project will require public hearings/ meetings to be held.
9	[Promoting public involvement] Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.	The law and current practices require that land acquisition and relocation orders for a specific site be disclosed several times over radio and in the printed media over a 1-month period, as well as display on-site. (ADB reports)	Only the radio would be useful for the illiterate to become informed of any pending land acquisition and resettlement activity on a specific site.	The project will require public hearings/ meetings to be held.
10	[Establishing grievance redness mechanism] Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	Vanuatu already has a Grievance redress system for general village matters, followed by the chief. MLNR has also recently been set up at Provincial level, through the Customary Land Tribunal. (Land Acquisition Act, Customary Land Tribunal Act)	No difference.	The project ensures an appropriate multiple level grievance redress system, which allows AP/DP participation, relatively rapid action and results, as well as encompassing existing grievance procedures.
11	[Identifying eligibility] Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits. (WB OP 4.12 Para. 6)	The law and current practice do specify census requirements and protocols for managing inflow of ineligible people. (Land Acquisition Act)	No difference.	For this project, a census of APs including inventory of losses and basic socio-economic information at household level will be undertaken. The inventory of losses will cover the value of impacted land, structures, business/ livelihoods and assets.
12	[Eligibility requirements] Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP 4.12 Para. 15)	No provision	Laws have no clauses that recognize encroachers in any way to be entitled or NOT entitled to compensation or rehabilitation.	The project will recognize encroachers, who are legitimately affected at the time of the census/ detailed measurement survey conducted.
13	[Land-to-land Compensation] Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP 4.12 Para. 11)	In Vanuatu, land acquisition, resettlement and compensation for land-based losses are included under the law. (Land Acquisition Act)	No difference	WB OP 4. 12 will be enforced to ensure that preference is given to land- based resettlement strategies for DPs whose livelihoods are land-based.
14	[Assistance during transition] Provide support for the transition period (between displacement and	In Vanuatu, land acquisition, resettlement and compensation for land-based losses are included under the law. (Land Acquisition Act)	Impacts to business and their employees are less clear and there is no recognizable	WB OP 4. 12 will be enforced in supplementing the Law of Vanuatu, in order to cover transition assistance requirements, business and

No.	JICA Guidelines	Related Laws/ Regulations in Vanuatu	Different Point	Policy to Bridge the Gap
	livelihood restoration). (WB OP 4. 12, para.6)		transitional support mechanism under the law.	employees impacted, as required.
15	[Consideration to vulnerable group] Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP 4.12 Para. 8)	No provision.	There is no recognition of vulnerable groups nor the consultation with or participation by APs at any part of the process, except in the case of people given the opportunity to make objections.	WB OP4.12 will be enforced in the prepared LAP and its implementation will require participation and consultation of vulnerable groups.

Source: JICA Study Team

(3) Policy for Land Acquisition in the Project

According to discussion with DOE and DOL, the basic policy for land issue in the project is to acquire the land, and the reason is that the hydropower facilities will be used to benefit the public.

Land for the hydropower facilities such as power plant, intake weir, conduit and head tank etc. are to be acquired, and land for the access road including transmission line is to be treated as Easement according to Land Acquisition Act.

Type of lease land was also considered by the DOE and DOL, but land acquisition process will be needed in the future after lease agreement. Therefore, lease agreement is not considered in the project.

1.3.2.4 Scale and Extent of Land Acquisition

(1) Affected Assets and Person

While there are no people living in the project site, land owner, land lessee and other assets such as crops, trees and cattle are affected by land acquisition of the project.

1) Land

496,000 m^2 land in total is affected by land acquisition of the project as shown in table below. Out of it, 482,000 m^2 land (97% of the total) is lease farm land (plantation) of PRV and 14,000 m^2 land (3% of the total) is customary land. Land owner of the project site is 4 persons and lessee is 1 company.

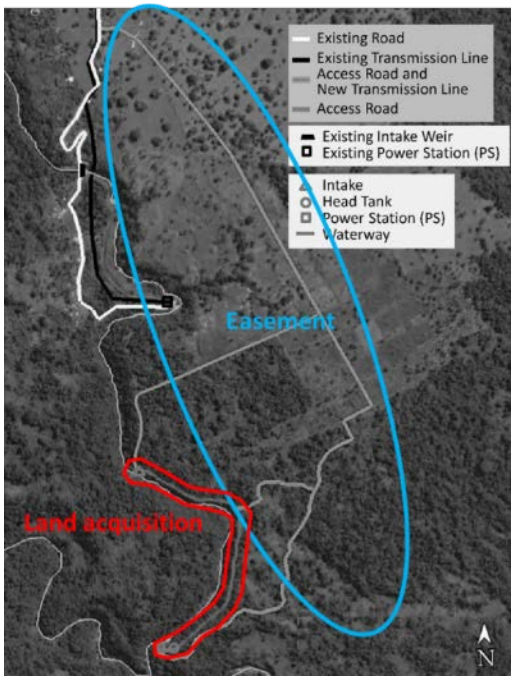


Figure 1.3-7 Image of the land acquisition

Table 1.3-23 Area of Affected Land

Type of Use	Classification	Compensation target	Area (m^2)	Total (m^2)
Permanent Use	Lease Land	Land owner: 4 Land lessee: 1	333,000	347,000
	Customary land	Land owner: 4	14,000	
Temporary Use	Lease Land (Residual soil yard)	Land lessee: 1	70,000	70,000
	Customary land	-	0	
Easement	Lease Land (Access road)	Land owner: 4 Land lessee: 1	79,000	79,000
Total of Lease land				482,000
Total of Customary land				14,000
Grand Total				**496,000**

The location and area acquired by this project was surveyed and determined by the DOL based on the design result of the survey.

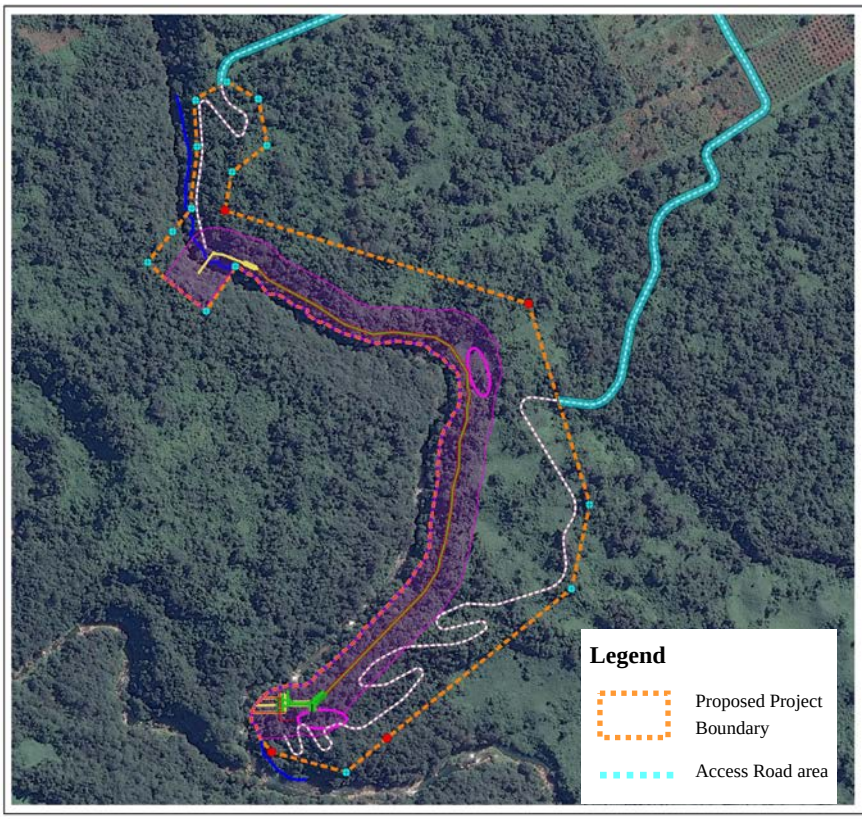


Figure 1.3-8 Range of the affected land

2) Affected Persons

As shown in Table 1.3-23, Four (4) landowners and one (1) Plantation Company are affected by land acquisition of the project. Although workers in the plantation have been

confirmed, only a part of the farmland is affected by the project, which is actually targeted for cultivation of agricultural products, and the working environment does not change significantly so that there is no loss to the workers.

3) Structure

There are no affected structures such as residence, commercial facility and building in the project site.

4) Agricultural Products/ Trees/ Cattle

Affected agricultural Products, trees and cattle are as follows.

Table 1.3-24 Affected Agricultural Products/ Trees/ Cattle

Category	Area	Type of Agricultural Products/ Trees/ Cattle	Subtotal	Total
Agricultural Products	Leased land (Plantation)	Kava plants (access road)	100	160
		Coconut trees (access road)	30	
		Pawpaw trees	30	
Trees		Nakatabol	50	80
		Natapoa	20	
		Bamboo trees	10	
Livestock		Cow	100	100

(2) Socio-Economic Situations

There are no affected people living in the project site. Therefore, socio-economic situation of the villages around the project site, namely Natoto, Monixhill and Fanafo is shown below for reference.

1) Population and Households

Population and households of the villages around the project sites are as follows.

Table 1.3-25 Population and Households of neighboring villages

Village	Population	Sex		Household
		Male	Female	
Natoto	60	-	-	-
Fanafo	1,290	670	620	258
Monixhill	309	157	152	62

2) Age Group

The majority of population in the Canal-Fanafo region is under the age of 20 and majority of household member is under the age of 15.

3) Education

Since Fanafo was historically a custom village, most people have not been to school. It was only after independence in 1980 that children were sent to school. But due to their strong belief and connection with the traditional norms, most children do not continue their education after primary level.

4) Occupation

Most household members of the families at Fanafo are subsistence farmers. Fanafo is known for its kava production and most members of the families' plant root (kumara, yam, taro, and manioc) crops and kava for the Luganville market, and kava is also shipped to the markets in Port Vila. A small number of male from the village work as truck drivers.

5) Traditional Structure

The villages of Monixhill and Fanafo have a traditional structured system where the chief has authority over the communities. Any matters that require the attention of the community, the chiefs of each island groups who settle in the village would call for meetings to discuss social issues affecting their communities.

1.3.2.5 Policies for Compensation and Assistance

(1) Loss Compensation

Under the project, the followings are the target of compensation or at least livelihood assistance.

- Those who lose lands (including farm lands), agricultural products, income, regular land-use rights and customary land-use rights are affected by the implementation of this project.
- Leaseholders (regardless with or without registration)

Details of compensation measures are as follows.

1) Land (Temporary use)

Qualified Persons	:	Lessees, Customary landholders
Compensation Coverage	:	Compensated by the leased land bill calculated based on the assessed value by the Valuer-General of the DOL. It is calculated considering the market price.
Procedure	:	Compensation contents and value are assessed by the Valuer-General of the DOL after the determination of land boundary, and determination of the compensation is presented to the landowners, lessors and the interested parties with 30 days for making their decision. If there is no complain against the determination, payment is conducted with the supervision of the Ministry of Finance.
Period	:	Total period for the compensation process is approx. 2 months

2) Land (Permanent use and Easement)

Qualified Persons : Lessees, Customary landholders

Compensation Coverage : Compensated by the valued price calculated based on the assessed value by the Valuer-General of the DOL. It is calculated considering the market price.

Qualified Persons : Illegal settlers (if any)

Compensation Coverage : Compensated for damages on non-land assets (agricultural products, trees, structures and etc.)
Note: Applied to the land for hydropower facilities

Procedure : Compensation contents and value are assessed by the Valuer-General of the DOL after the determination of land boundary, and determination of the compensation is presented to the landowners, lessors and the interested parties with 30 days for making their decision. If there is no complain against the determination, payment is conducted with the supervision of the Ministry of Finance.

Period : Total period for the compensation process is approx. 2 month.

3) Agricultural Products and Trees

Qualified Persons : Producers of agricultural products (regardless of whether ones are legal or illegal)

Compensation Coverage : Made to be harvested as much as possible by issuing harvest notification before land acquisition. However, the agricultural products which cannot be harvested are going to be compensated at reasonable cost by cash.

Procedure : Compensation contents and value are assessed by both the Department of Forestry and the Department of Agriculture after the determination of land boundary, and determination of the compensation is presented by the DOL to the landowners, lessors and the interested parties with 30 days for making their decision. If there is no complain against the determination, payment is conducted with the supervision of the Ministry of Finance.

Period : Total period for the compensation process is approx. 2 month.

Note : Applied to the land for hydropower facilities and access road

4) Unforeseen or Unintended Impacts

Qualified Persons : Persons directly or indirectly affected by this project (unforeseen impacts).

Compensation Coverage : Applying the compensation coverage from 1) to 3), the others shall be compensated according to the JICA Guideline and etc.

The Cut-off date of this project is 17th of June 2019, which is the date of the public hearing before the start of environmental and social survey.

(2) Livelihood Assistance Plan

Since this project is not going to cause resettlement or land acquisition in large scale, its impacts on the daily lives of residents are limited. Thus, it is not expected to cause forced loss or change of jobs. According to the consultations, it became clear that the early implementation of this project is preferred as it is beneficial to the public. In addition, local residents expect to be actively employed as construction workers.

As there will be no loss to sellers and their related producers during the construction, the livelihood compensation is not necessary.

(3) Entitlement Matrix

Draft entitlement matrix which lists the types of asset losses, application, definition of affected persons and compensation coverage is as follows.

Table 1.3-26 Draft Entitlement Matrix

Types of Loss	Application	Definition of Affected Persons	Compensation Coverage
Land for Temporary Use	Land to be used during construction	Lessor/ Lessee/ Customary Landholder/ Land user	Necessary to agree with landholders or affected persons. Affected landholders and persons shall be paid for an agreed lease expense. After use, the land shall be returned to owners after restoration of the land to its original condition.
Land for Permanent Use	Acquired land	Lessor/ Lessee/ Customary Landholder/ Land user	Compensation in money based on replacement cost or provision of land which has equivalent area and quality.
		Illegal settlers without legal rights	Compensation for non-land assets (agricultural products, trees, structures and etc.) in the land affected by this project.
Agricultural Products and Trees	Agricultural products and trees in affected land	Owners of agricultural products or trees (regardless with or without legal/ customary rights)	Harvest notification of agricultural products and trees is issued before land acquisition. If harvest is impossible, compensation is made in monetary form based on replacement cost (market price).
Unforeseen or Unintended Impacts	Impacts revealed by the detailed design	Affected residents	Complying with JICA guidelines for other cases which are not covered by the above points

1.3.2.6 Grievance and Complaints Redress Mechanism

(1) Introduction

A Grievance Redress Mechanism (GRM) is to receive and facilitate resolution of affected stakeholders' concerns and grievances related to the Project's environmental and social performance. The GRM process should be disclosed publicly and available during the pre-construction, construction and operation phases of the Project, and to be used by all affected stakeholders, including employees and contractors.

Grievances should be received, recorded/ documented and addressed in a manner that is easily accessible, culturally appropriate and understandable to affected communities. Where feasible and suitable for the Project, the grievance mechanism may utilize existing formal and informal grievance mechanisms, which will support the Project-specific proposed arrangements. The Project dedicated personnel on handling grievances will be consistent, experienced and qualified to do so.

The communities will be informed about the GRM during the stakeholder consultation and disclosure activities. The mechanism will be communicated and made available to all affected communities and in particular to both genders and vulnerable groups.

The Project dedicated personnel will be experienced and/or trained to seek solutions to complaints in a collaborative manner with the involvement of the affected community, taking into consideration customary and traditional methods of dispute resolution, and not impeding access to existing judicial or administrative mechanism available in the country for resolution of disputes. The mechanism includes a redress aspect so that those who feel their complaint has not been addressed in a manner they find satisfactory can have recourse to an external body for reconsideration of their case.

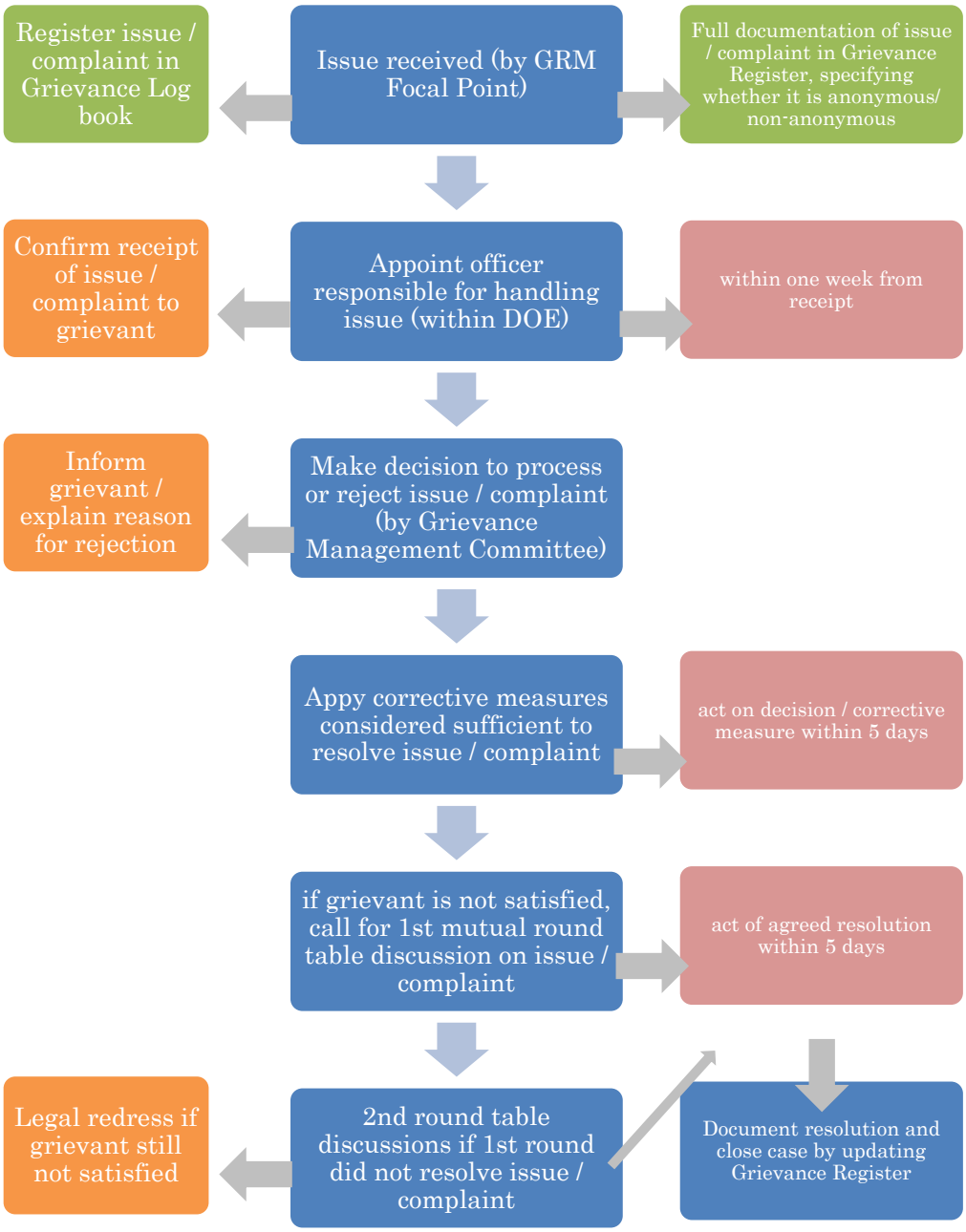
Concerns will be addressed promptly, using a transparent process that is readily accessible to all segments of the affected communities and at no cost to them and with no retribution. Grievances received and responses provided will be reported back to the community periodically (at least every six (6) months).

(2) Procedure

Grievance and complaints redress procedures are shown by level as follow. Duration of each stage will be agreed with the DOE and included in the disclosure to communities

The GRM Focal Point is selected by DOE and its contact details must be made available to all stakeholders. Grievances can be made by anyone to the GRM Focal Point within DOE. The GRM Focal Point will work with DOE officers to support the handling of complaints brought to the attention of the GRM Focal Point, and will be the secretary of the Grievance Management Committee.

The Grievance Management Committee, is comprised of members from GRM Focal Point, the DOE offices supporting the handling of complaints, representatives from the Project development. Its task is to discuss and steer how to address issues / complaints. The Grievance Management Committee should gather when issues / complaints are received, and in any case on a monthly basis.



Source: VREP Stakeholders Engagement Framework, 2019

Figure 1.3-9 Grievance Redress Mechanism Tracking

1.3.2.7 Implementation System

(1) Driving Organization

1) Department of Energy (DOE)

DOE is the main driving organization in this project and implements land acquisition and compensation by executing and supervising the project in coordination with related organizations. DOE also budgets at a suitable time during the LAP implementation and secures the budget to enforce.

2) Department of Land (DOL)

DOL is comprised of five sections such as 1) Land Survey, 2) Land Management, 3) Land Registry, 4) Customary Lands Tribunal and 5) Valuer General's Office. Therefore, the department is responsible for all procedures related to land such as identification, valuation, computation of compensation values, tenure transfer and complaint handling for the land to be acquired, when endorsing a request from the project entity.

3) Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity (MALFFB)

The MALFFB plays a role in computing compensation for agricultural products and trees during land acquisition. The computation is based on the results of socio-economic survey carried out by the project entity. In collaboration with DOL, the MALFFB evaluates the fair compensation values by confirming land classification and attribution.

(2) Supporting Organizations

1) Department of Environmental Protection and Conservation (DEPC)

DEPC is responsible for all activities regarding the EIA in Vanuatu. A close collaboration with DEPC is essential because land acquisition is tightly combined to the environmental policy.

2) Sanma Province Government

The Sanma provincial Government, in which the project site is located, collaborates with the central governmental units and the local community to mainly carry out land acquisition and handle complaints after it is devolved by the central government.

3) Local Communities (Monixhill, Fanafo, Natoto)

Communities of Monixhill, Fanafo and Natoto are not involved in the project directly, but in the community, which is managed by the chief, most members are deemed as stakeholders of the project. It is necessary to have the support of people from these communities to smoothly execute the Project by acquiring customary lands and resolving conflicts among the affected people.

4) NGO

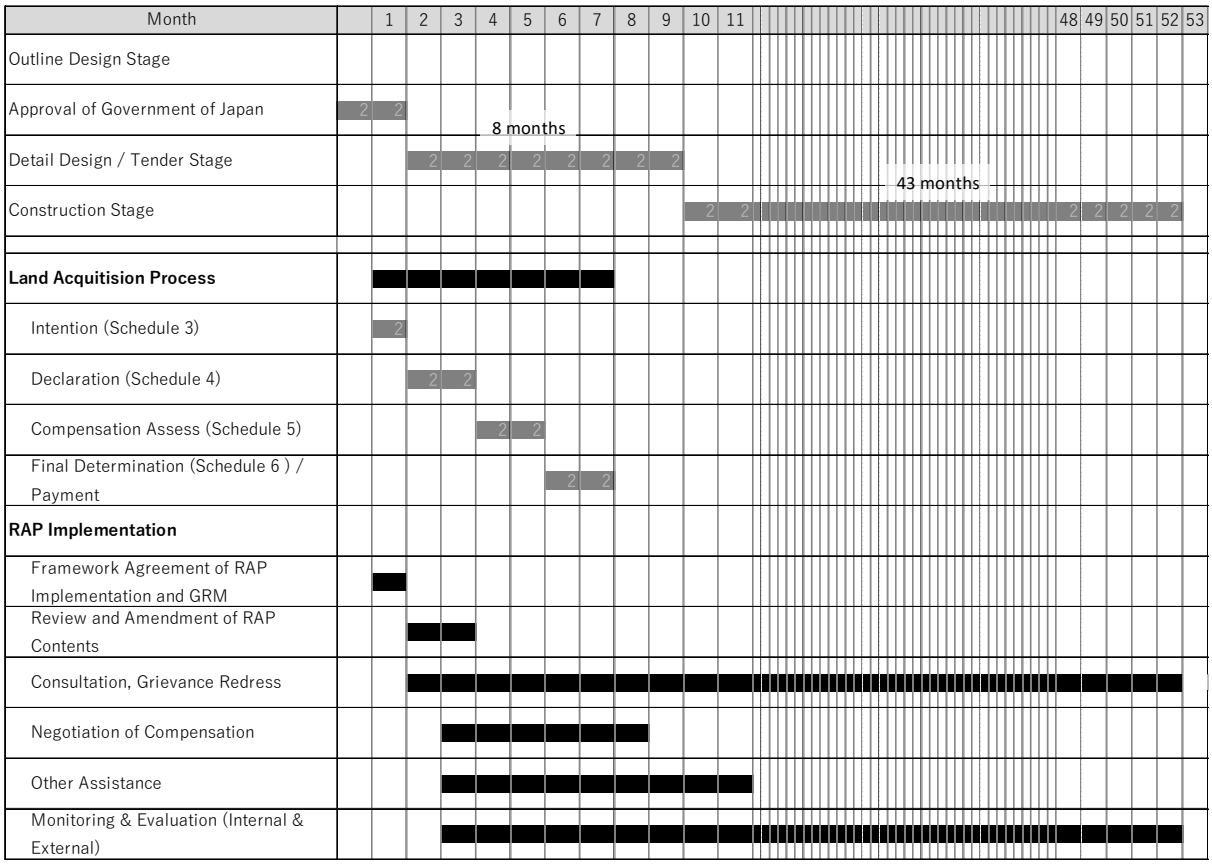
NGOs are those who support strict implementation of the project as a third party for land acquisition and external monitoring of compensation. For instance, Oxfam Vanuatu, which has been operating widely in Vanuatu, deals with gender issues which has become prominent recently in the country, and has contributed to empowering the socially vulnerable and eliminating sexual violence

1.3.2.8 Implementation Schedule

Implementation schedule for land acquisition and compensation is shown below. The draft LAP will be amended and finalized by revising the location and area of the acquired land and re-computing the compensation values in case the content of outline designs would be revised during the detailed design stage. On the other hand, prior to these activities, the project entity establishes the project management unit for LAP and grievance redress framework. In tandem

with these activities, the project entity starts public consultations, advertising activity, complaint handling, and monitoring/ evaluation (internal and external) until the completion of the project. Negotiations with the land owner and lessor/lessee to reach an agreement are commenced in accordance with the construction progress, and the payment of compensation shall be finished before the commencement of construction. Preparations to restore the livelihood of affected people and others shall be commenced by the project in tandem with the negotiations with the affected people and its agreement.

Table 1.3-27 Schedule of LAP Implementation



1.3.2.9 Costs and Budget

Estimated cost related to land acquisition and LAP implementation are as follows. The costs shall be updated in the review of LAP at the time of the detailed design. The costs shown here shall be budgeted according to the budget rules of in Vanuatu by the project implementation organization (DOE).

Table 1.3-28 Cost Estimate for LAP Implementation

Item		Amount (VUV)	Note
Assets (Land/ Buildings)	Land (Permanent Use)	33,000,000	Estimated based on valuation (replacement cost) by DOL.
	Land (Temporary Use)	7,000,000	Tentative price. This depends on the negotiation between the leaseholder and the DOE.
	Buildings	0	-
	Subtotal (1)	40,000,000	
Compensation/ Support	Agricultural products/ Trees	8,318,000	Estimated based on Agriculture Compensation Policy.
	Livelihood Support	0	-
	Inconvenience Fee	400,000	To PRV
	Support for Socially Vulnerable Households	0	-
	Subtotal (2)	8,718,000	
Total (3)		50,000,000	Approximately (1) + (2)
LAP Activity Cost	(4)	7,500,000	15% of Total (3) (round-off)
Physical Contingency	(5)	2,875,000	5% of Total (3) + (4) (round-off)
Grand Total		**60,375,000**	**(3) + (4) + (5)**

1.3.2.10 Monitoring System by the Project Entity

A monitoring will be conducted to evaluate whether the land acquisition process and compensation activities are implemented as planed in the LAP. In the monitoring, regular data collection with analysis and reporting on the progress shall be done throughout the entire land acquisition activities.

(1) Internal Monitoring

The project entity (DOE) conducts the supervision and in-house monitoring of the LAPs implementation and will be alternately called the Internal Monitoring Agent (IMA). The IMA will assign internal staff of DOE or local consultants as the members of IMA. Tasks of IMA include:

- Regularly supervising and monitoring the implementation of the LAPs in coordination with the related organizations and the community around the project site. The findings will be documented in the quarterly report to be submitted to JICA and the supervising body;

- Verifying that the valuation of assets lost or damaged, the provision of compensation and other entitlements, and relocation, if any, has been carried out in accordance with the respective LAP;

- Ensuring that the LAP is implemented as designed and planned; and

- Recording all grievances and their resolution and ensuring that complaints are dealt with promptly.

(2) External Monitoring

An External Monitoring Agent (EMA) will be commissioned by DOE to undertake independent external monitoring and evaluation. The EMA for the project will be either a qualified individual or a consultancy firm with qualified and experienced staff. A local NGO, an academic institution or a local consulting firm may be commissioned for the EMA. The tasks of the EMA shall include:

- Verifying results of internal monitoring;
- Verifying and assessing the results of the information campaign for PAHs rights and entitlements;
- Verifying that the compensation process has been carried out with the procedures communicated with the PAHs during the consultations;
- Assessing whether land acquisition objectives have been met;
- Assessing efficiency, effectiveness, impact and sustainability of land acquisition and implementation;
- Reviewing how the compensation rates were evaluated; and
- Reviewing the handling of compliance and grievances cases.

(3) Monitoring Indicators

Monitoring indicators for internal and external monitoring activities in this LAP are shown below.

Table 1.3-29 Internal Monitoring Indicators

Monitoring Indicators	Basis for Indicators
1. Budget and Timeframe	• Have all land acquisition staff been appointed and mobilized for the field and office work on schedule? • Have capacity building and training activities been completed on schedule? • Are LAP being achieved against the agreed implementation plan? • Are funds for LAP being allocated to LAP agencies on time? • Have LAP offices received the scheduled funds? • Have funds been disbursed according to the LAP? • Has the social preparation phase taken place as scheduled? • Has all land been acquired and occupied in time for project implementation?
2. Delivery of Compensation and Entitlements	• Have all affected persons (APs) received entitlements according to numbers and categories of loss set out in the entitlement matrix? • Have APs received payments for affected structures and lands on time? • Have APs losing from temporary land borrow been compensated? • Have all land contracts been concluded? Was the land developed as specified? Are measures in train to provide land titles to APs? • Isn't there expropriation to APs? • How many APs households have received land titles? • Have affected businesses received entitlements including transfer and payments for net losses resulting?
3. Public Participation and Consultation	• Have consultations taken place as scheduled including meetings, groups, and community activities? Have appropriate land acquisition leaflets been prepared and distributed? • How many APs know their entitlements? How many know if they have been received? • Have any APs used the grievance redress procedures? What were the outcomes? • Have conflicts been resolved? • Was the social preparation phase implemented?
4. Benefit Monitoring	• What changes have occurred in patterns of occupation, production and resources use compared to the pre-project situation? • What changes have occurred in income and expenditure patterns compared to pre-project situation? What have been the changes in cost of living compared to pre-project situation? Have APs' incomes kept pace with these changes? • What changes have taken place in key social and cultural parameters relating to living standards?

Table 1.3-30 External Monitoring Indicators

Monitoring Indicators	Basis for Indicators
1. Basic Information on APs	• Location • Composition and structures, ages, education and skill levels • Gender of household head • Ethnic group • Land use and other resource ownership patterns • Occupation and employment patterns • Income sources and levels • Agricultural production data (for rural households) • Value of all assets forming entitlements
2. Compensation Process	• Were land compensation payments made to the APs? • Have compensation process been implemented without problem and efficiently?? • Have compensation been conducted according to the result of discussion with APs?
3. Levels of APs' Satisfaction	• How much do APs know about land acquisition procedures and entitlements? Do APs know their entitlements? • How much do APs know about grievance procedures and conflict resolution procedures? How satisfied are those who have used said mechanisms.
4. Effectiveness of land acquisition Planning	• Were the PAHs and their assets correctly enumerated? • Was the time frame and budget sufficient to meet objectives? • Were entitlements too generous? • Were vulnerable groups identified and assisted? • How did land acquisition implementers deal with unforeseen problems?
5. Other Impacts	• Were there unintended environmental impacts? • Were there unintended impacts on employment or incomes?

1.3.2.11 Public Consultation

The public consultations on land acquisition were held along with those for the environmental impact assessment (EIA), because the impacts to the project area and local people were considered minimum. Refer to section 1.3.1.11 for the detailed contents of consultation.

1.3.3 Environmental and Social Monitoring Form

Environmental and social monitoring form is attached in the reference.

Environmental and Social Monitoring Form (1/5)

The Project for the Construction of Hydropower Station in Espiritu Santo Island
Environmental and Social Monitoring Form

1. Response/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from Government agencies	

2. Pollution

1) Air Quality

Item	Unit	Situations of Dust Based on the observation	Monitoring Point	Frequency
Dust	-	1. Good 2. Acceptable level 3. Bad	Construction site	Daily

2) Surface Water Quality

Item	Unit	Measurement Point			Target Standards for Contract	Referred Standards	Frequency
		Discharge point of the turbid water	Down-stream of Sarakata river	Up-stream of Sarakata river			
Turbidity or Suspended Substance (SS)	NTU or mg/l			-	SS: 200 mg/L or equivalent value of Turbidity	Japan's standard	weekly
Oil & grease	Yes/No			-	observed		

3) Waste (Construction waste)

Date: Item: Waste Management Mark: "✔" if management is done as required

Location	Kind of waste	Volume of waste (m3)	Final disposal or reuse	Stored at designated place	Waste separation	Remark

4) Mitigation Measures

Date: Mark: "✔" if mitigation measure is done

No	item	Monitoring Site	Mitigation measure is done or not Conditions of facilities	Remarks	Frequency
1	Check the conditions of vehicles (dust & noise control)	Project site			Daily
2	Sprinkling (dust control)	Project site			Daily
3	Washing tires (dust control)	Exit of the project site			Daily
4	Condition of temporary cofferdam	Riverbank at the project site			Daily
5	Condition of sedimentation pond/drainage	Discharge point			Daily

Environmental and Social Monitoring Form (2/5)

3. Natural Environment

1) Ecosystems

Item	Monitoring Site	Monitoring Results during Report Period	Measures to be Taken	Frequency
Clearance condition to avoid/limit the loss of habitat (visual inspection)	Project site			Weekly
Identifying Important species such as *Pteropus. anetianus* (Vanuatu Flying Fox) (visual inspection) and Cupaniopsis neo-ebudicum.	Project site			Weekly

2) Hydrological Situation

Item	Monitoring Site	Monitoring Results during Report Period	Measures to be Taken	Frequency
Impact of construction work on steep slope (visual inspection)				Weekly
Impact of operation of hydropower facilities on river channel (visual inspection)				Twice a year (Dry & Wet season)

Environmental and Social Monitoring Form (3/5)

4. Social Environment

1) Land acquisition

Pre-Construction phase

Resettlement, Land expropriation, and compensation for assets and crops (monthly report)

Item	Planned Total	Unit	Month/Year		Month/Year		Month/Year		Month/Year		Month/Year		Expected completion date	Responsible organization
			Qty	%	Qty	%	Qty	%	Qty	%	Qty	%		
1.Update PAPs list and Final Asset Valuation														DOL
1-1 Identification of final PAHs*	-	HH Business												
1-2 Announcement to Affected people	-	Time												
1-3 Inventory survey and final cost estimation for expropriation	-	Time												
1-4 Consultation meeting times	-	Time												
1-5 Agreement signed by PAHs*	-	HH Business												
2. Progress of resettlement														
2-1 Resettlement of household	-	HH												
3. Progress of land acquisition														DOL
3-1 Permanent land acquisition Customary land	13,000	m2												
3-2 Permanent land acquisition Leased land	337,000	m2												
3-3 Temporary land use Leased land	70,000	m2												
4.Progress of compensation in cash														DOL
4-1 Agricultural Products	140	num.												
4-2 Trees	73	num.												
4-3 Livestock	100	num.												
5. Complain and Grievance Redress N/A Cases		Case												
5-1 Solved cases		Case												
5-2 Unsolved cases		Case												

Environmental and Social Monitoring Form (4/5)

Record of Complain and Grievance Management

No	Date	Complain and Grievance from PAPs	Solution / Result / Any actions to be taken

Consultation meetings

No	Date	Sector	Nos of Participants	Key agenda and result of discussion

2) Livelihood

Before Construction

Item	Monitoring Results during Report Period	Measures to be Taken	Frequency
Priority in Employment			Monthly
Other employment			Monthly

3) Safety Management (Health and Occupational Safety)

Safety management plan

Pre-construction phase

	Safety management plan is prepared and submitted	Approved by the Consultant	Remarks
Date			

Training programs

No		Date	Training	Agenda	Participant
1					
2					

During Construction

Safety management

Date:

No	item	Result	Remarks
1	Number of meetings organized since the previous monitoring		
2	Safety gear distribution (%)		
3	Keep records of accidents and injuries properly (Yes/No)		
4	Installation of fences, assignment of guards (Yes/No)		

Environmental and Social Monitoring Form (5/5)

Record of Accidents

No	Date	Details of accidents	Solution / Result / Any actions to be taken

4) Other checklist

Date: Mark: "✔" if mitigation measure is done

No	item	Monitoring Site **	Mitigation measure is done or not	Remarks
1	Communities get the information on the construction schedule			
2	Communities know get the information of traffic management			
3	Installation of signboard			
4				

5) Record of Complains

No	Date	Complains	Solution / Result / Any actions to be taken

1.4 Preparation for the Global Climate Fund (GCF)

Based on the discussion between the Vanuatu side and Japanese side, the Concept Note for the Global Climate Fund (hereinafter referred to as "GCF") was prepared that can contribute to the policy goal of the government of Vanuatu concerning the climate change, to achieve 100% renewable energy by 2030. The both sides confirmed the option A is preferable considering cost and benefit balance. The Executing Agency will obtain consensus among the concerned departments of the government, and submit the proposal to the designated authority so that the proposal is appraised at the earliest evaluation process of GCF secretariat.

The contents of the proposal of the Concept Note was shown below;

(1) Project / Programme details

1) Context and Baseline

The Republic of Vanuatu is a small archipelagic island country, which consists of 83 islands, stretching over 1,300 km from north to south in the Western Pacific Ocean. Major islands have volcanic mountainous terrain, including several active volcanos, which have been erupting for many years, causing serious natural disasters such as volcanic eruptions, earthquakes, tsunami continuously. Also, Vanuatu is topographically located on the passage route of the tropical cyclones. Only in the past 10 years, Vanuatu has been hit by 20-30 cyclones, of which several cyclones caused catastrophic damage. Recently, a cyclone named PAM caused a great deal of damage throughout the country in 2015. These natural disasters have a huge negative impact on the economic growth. Moreover, amongst the small island developing states (SIDS), Vanuatu is considered to be one of the most vulnerable countries to climate change. This has had a negative impact on all sectors—agriculture, water, coastal and marine resources, tourism and infrastructure etc.

Electricity power supply on the islands used to be dependent on the diesel power plant generation with isolated grid because interconnection with other islands was difficult, which makes energy cost and greenhouse gas emission higher.

The proposed location of Espiritu Santo Island (Santo Island) is the largest island, and the town of Luganville is Vanuatu's second-largest city which accounts for 20% of total population in Vanuatu. Santo is producing a huge quantity of Beef, Copra, and Kava, for both domestic consumption and export. Also, Santo's beautiful environment, especially the coastal and marine resources attract most of the tourist traffic amongst the outer islands (in Vanuatu, tourism is a fast-growing sector,).

Stable electricity supply is critical for the economic growth of tourism industry and the other industries such as kava and meat processing factory in Santo. The proposed project is designed to align with the Updated National Energy Road Map (Updated-NERM) to establish a power system, fully based (100%) on renewable energy by 2030 as a way to reduce GHG (Green House Gas) emissions; provide affordable, reliable energy access; and facilitate green growth . This Updated-NERM target would replace nearly all fossil fuel requirements for electricity generation in the country. This contribution would reduce emissions in the energy sector by 72Gg by 2030.

In Santo, as an implementing agency of ODA, JICA; Accredited Entity (AE) for this project, had implemented a project to construct the Sarakata River Hydroelectric Power Station as a grant aid project in 1994 and 2005. And this renewable energy power generation has been

the main power source for the Luganville grid system. However, due to the increasing power demand in the island, it is necessary to generate power using diesel power generation even for the night time. Moreover, the peak demand is expected to increase to 2,800kW by 2030, and the total coverage ratio of renewable energy will drop down from 68 % in 2017 to 38% in 2030. Given such a situation, in order to meet the Updated-NERM target, JICA and Vanuatu's relevant authorities including Department of Energy (DOE) have come together and come up with the "100% renewable energy project", which includes components such as construction of a new hydropower plant, PV, battery, new construction and upgrading of transmission line. In addition, the project component includes the capacity building component (technical assistance), which could play an important role in the paradigm shift mentioned in the Updated-NERM. This project could be replicated to other islands of the nation and further spread to other Pacific Island Countries.

2) Project / Programme description

The Implementation of Roadmap is focusing on increasing of the share of renewable energy in electricity generation. The target of the government of Vanuatu is "close to 100% renewable energy in the electricity sector by 2030". In order to achieve this target, the activities proposed in this programme will contribute to increase the share of renewable energy. The components of this programme are shown below;

Component-1: New Hydropower Plant (Sarakata-2, 1,000kW)

New hydropower plant is planned to be developed by Japanese Government Grant Project at downstream of the existing hydropower (Sarakata-1) plant on the Sarakata River. The installed capacity of the new hydropower (Sarakata-2) will be 1,000kW.

Component-2: Expansion of Existing Hydropower Plant (Expansion of Sarakata-1, 300kW)

Vanuatu Utilities Infrastructure Limited (VUI), a concessionaire to supply electricity in the Santo Island, plans to expand the existing Sarakata-1 Hydropower Plant adding 300kW by their own fund.

Component-3: Additional Transmission Line from Sarakata to Luganville (2-lined transmission line)

Since the existing transmission line from Sarakata-1 to Luganville S/S (20kV) is the single line, the electricity supply tends to disconnected because of line accidents, power failure, and natural disaster such as cyclones. The main electricity supply is currently made by the Sarakata-1. When the Sarakata-2 is to be operated, the importance of the transmission line from Sarakata to Luganville will be increased. Therefore, upgrading the transmission line is essential to improve reliability of supplying electricity and infrastructure resilience. By constructing additional transmission line, the transmission loss will be decreased as well as improving the reliability, which will contribute to increase the share of renewable energy.

Component-4: Installation of PV Facility

PV facilities are planned to be installed to compensate the decreased electricity power generation by hydropower during dry season. The PV system will contribute to increase the share of renewable energy even in dry season by substituting the power generation by diesel.

Component-5: Installation of Battery System

The Battery system is planned to be installed to store the electricity generated by Hydropower plant and PV facilities in the daytime and supply in the peak hours. By replacing the night time usage of diesel oil to the usage of battery system, it will contribute the share of renewable energy even in dry season

Component-6: Technical Assistance (TA)

The components of above introduced programme such as combining low carbon technologies: Hydropower, PV and battery systems, will be the advanced case for Vanuatu. In order to utilize hydropower, PV and battery system effectively, combination and optimization between weather and hydrological forecast in the short and middle term and power demand and supply forecast will be important to be reflected to manual and standards of operation and maintenance for the staff of DOE and concessionaire. After installation of equipment and facilities, the study on above subjects will be conducted under the technical assistance in parallel with usual operation. Once the knowledge of operating the system is to be established in the Santo Island, these system will be spread to all over other islands in Vanuatu, which will contribute to increase the share of renewable energy in all over Vanuatu.

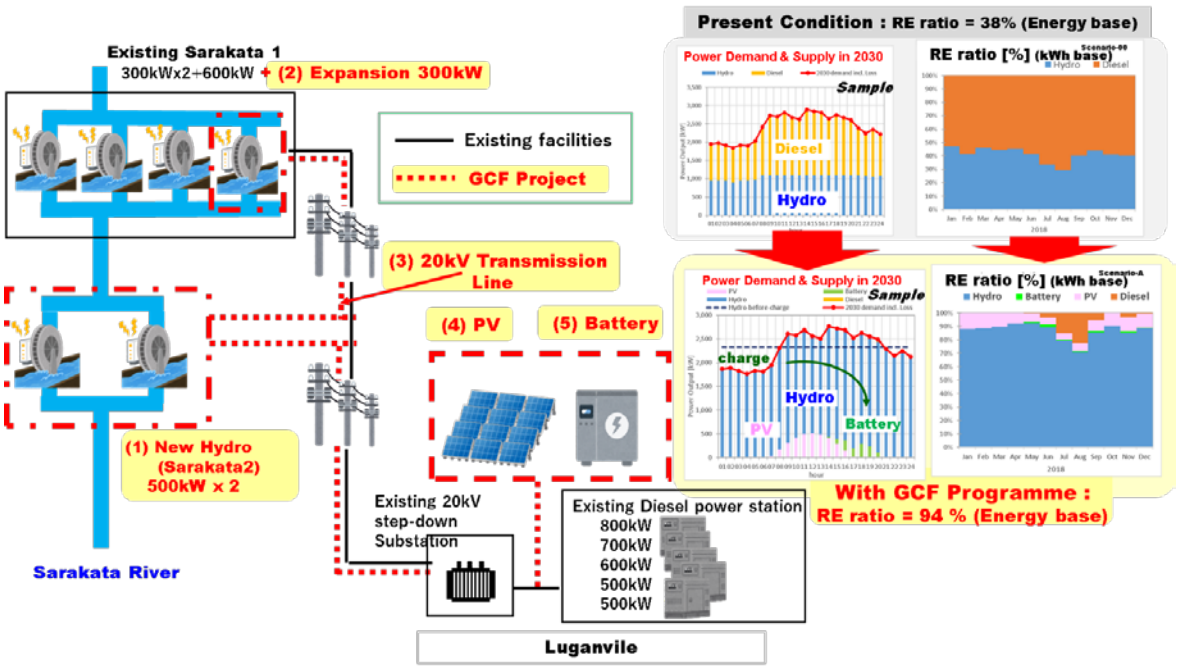


Figure 1.4-1 Overview of the Programme

3) Expected project results aligned with the GCF investment criteria

Impact Potential

This programme consists of hydropower plants, PV plants, batteries and energy management system with 2-lined transmission line, will contribute to reduce 10,675 MWh/year diesel power generation shifting to renewable energy power generation. The reduced diesel fuel cost will be 2,710,000 USD per year.

Paradigm Shift

Electricity power supply on the islands used to be dependent on the diesel power plant generation with isolated grid because interconnection with other islands was difficult. Fortunately, large amount of electricity power on the Santo Island used to be provided by Sarakata-1 hydropower plant on the Sarakata River as well as diesel power generation. The main power demand center is Luganville city, which is far from the Sarakata hydropower plant. Therefore, power supply is easy to be disconnected by accidents of the transmission line, fallen trees, and natural disasters such as cyclones because the transmission line from Sarakata and Luganville is only a single line. Once this programme to be implemented, 2-lined transmission line will contribute to improve reliability of supplying electricity and infrastructure resilience.

Sustainable Development Potential

Environmental Benefit: Environmental Sustainability is the cornerstone of the project design. Renewable energy generation from hydro and solar power will reduce reliance on imported fossil fuel and facilitate to reduce the GHG emissions. Moreover, the reduced usage of diesel fuel could also result in the reduction of transportation fuel and GHG emissions. It should be noted that the project contributes to climate change mitigation effort by satisfying the electricity demand with clean and sustainable energy.

Social Benefit: The anticipated benefits are 1) reducing tariffs for electricity, 2) improved reliability of electricity supplies, 3) develop a resilient society for disasters such as climate change and 4) improve the educational opportunities and access to health-care treatment. These will lead to more social and cultural benefits, for example, a local resident could improve the awareness of using renewable energy and its importance, which in turn could enhance the image of their hometown. As for the gender aspect, the use of renewable energy can deliver equal opportunities such as providing income-generating opportunities for both men and women at all stages.

Needs of Recipient Country

The proposed project is highly expected to achieve the goal of Updated-NERM by 2030. Also, the project will accommodate climate change mitigation needs of recipient country such as shift toward renewable energy from dependence on fossil fuels, improvement of energy self-sufficiency rate to ensure of energy security and reduction of greenhouse gas emissions. In addition, the project will contribute to the formation of resilient infrastructures to adapt climate-driven extreme disasters. Since it is difficult to develop these infrastructures on a limited budget of Vanuatu Government, promotion of renewable energy in Vanuatu would be contributed by utilization of GCF.

Country ownership

Project's Executing Entity (EE): Department of Energy (DOE), which is placed under the Ministry of Climate Change and Adaptation (MOCCA) in Vanuatu has full responsibility for achieving the Updated-NERM target as an energy sector's implementing agency. The Department of Climate Change (DOCC) which is recently appointed as the Vanuatu's National Designated Authorities (NDA) of GCF is also placed under the MOCCA, in parallel with DOE. Both EE and NDA have developed solid cooperation system for this project implementation and operation.

Efficiency and Effectiveness

This Programme consists of hybrid renewable energy sources system including, hydropower, PV, and battery. The costs and mitigation targets for the envisaged GCF SAP project are summarized as follows;

a) Total Program Cost :52 million USD
b) Requested GCF amount :10 million USD
c) Fuel (diesel) consumption reduction :3,203 litres/year
d) Fuel cost reduction :2.71 million USD/year
e) Expected annual tCO_2eq reductions: 1,530,360 tCO_2/year

As for the cost effectiveness and efficiency, total detailed cost estimation will be calculated in further study. Since concerned technologies are progressing year by year, AE continually observe and assess the prices, efficiency and effectiveness to ensure that best available at the time of project implementation. As a result of further studies, programme components should be considered in the view of not only from a cost-effectiveness perspective but also a life cycle cost.

(2) Indicative financing / Cost information

1) Financing by components

Financing by components are shown below.

Table 1.4-1 Financing by Components

Component	Output	Indicative cost (USD)	GCF financing		Co-financing			
			Amount (USD)	Financial Instrument	Type	Amount (USD)	Financial Instrument	Name of Institutions
New Hydropower (Sarakata-2)	New Hydropower (Sarakata-2)	38,000,000	0	Choose an item.	Public Source	38,000,000	Grants	JICA
Expansion of Existing Hydropower (Sarakata-1)	Expansion of Existing Hydropower (Sarakata-1)	2,000,000	0	Choose an item.	Private Source	2,000,000	Choose an item.	VUI
Transmission Line	Transmission Line	3,000,000	3,000,000	Grants		Enter amount	Choose an item.	Click here to enter text.
PV	PV	2,000,000	2,000,000	Grants		Enter amount	Choose an item.	Click here to enter text.
Battery	Battery	4,000,000	4,000,000	Grants		Enter amount	Choose an item.	Click here to enter text.
Technical Assistance	Technical Assistance	1,000,000	1,000,000	Choose an item.		Enter amount	Choose an item.	Click here to enter text.
Indicative total cost (USD)		47,000,000	10,000,000		37,000,000			

2) Justification of GCF Funding Request

One of the main objectives of the GCF is to contribute to the reduction of GHG. In the Updated-NERM, Vanuatu aims at a GHG reduction in the energy sector by 72Gg by 2030. Despite the good political will of the country, responses to climate challenges are still limited for various reasons such as financial and technical constraints. In addition,

Vanuatu's electricity supply is operated by the concessionaire and imposing installation cost on the concessionaire, such as VUI is not realistic. Also, considering national budget of Vanuatu, the Government does not have enough budget to allocate the installation cost of 2-lined transmission line, solar panels and battery storage as a priority even though Luganville is the second largest city in Vanuatu. As this project is aimed to contribute to the reduction of GHG and enhancing the resilience of climate change in one of the most climate vulnerable island country, applying GCF fund will be fully justified.

3) Exit Strategy and Sustainability

Power generation equipment used for renewable energy (hydropower and solar power) require lesser maintenance fee compared to the generation by diesel oil, which could cut down the maintenance cost. In addition, there are fewer expendable parts when compared to the diesel generation. Therefore, this project will result in economic sustainability. Moreover, renewable energy generation will not require diesel fuel and save the huge amount incurred in fuel fees. The Government of Vanuatu can further invest in renewable energy related project using their own savings, which will also enhance the environmental sustainability. By combining the TA, the trained local engineers could maintain the operation with their own skills. Also, developing a concrete manual will assist the local engineers to transfer their maintenance knowledge, and this will benefit the other islands in case study.

4) Stakeholders engagement in the project or programme

The proposed GCF SAP project and the Concept Note has been developed in close cooperation with key stakeholders from AE (JICA), EE (DOE), and fully supported by NDA (DOCC) and VUI: concessionaire which was appointed by the Government of Vanuatu. These key stakeholders brought together and recent multilateral consultations on forming project component were conducted on November 2019 in Vanuatu. The above stakeholders were actively engaged in the design process of the Concept Note, also on defining their roles within the proposed project. To further enhance cooperation and communication among the key stakeholders, DOE under the MOCCA will take an important role for coordinating the project.

Capacity of AE : JICA implemented a project to construct the Sarakata River Hydroelectric Power Station as a grant aid project, and it has been operated over 2 decades as a main power source of the Santo Island. Also, JICA launched the strategy called "Island Hybrid Initiative" in the pacific island regions and has been leading several renewable energy projects (such as solar, wind) over decade. The long term experience and high engineering technology will contribute to developing this 100% renewable energy project more effectively.

Capacity of EE; DOE has enough experience and knowledge for implementing and operating projects since they have been working on the renewable energy projects with other international partners. This experience will enable the efficient and effective project implementation for this proposed project.

2. Contents for the Project

2.1 Basic Concept of the Project

This Project, "the Construction of Hydropower Station in Espiritu Santo Island", is to develop a 1,000 kW scale hydropower station at the downstream of the existing Sarakata River Hydropower Station, as well as to construct access roads, transmission lines, and setting transformers for this Project.

Table 2.1-1 Salient Features of the Project

Power Generation Type		Run-of-River type	
Installed Capacity	Total	kW	1,000
	Single	kW	500
Plant Discharge	Total	m^3/s	4.2
	Single	m^3/s	2.1
Head	Gross Head	m	33.0
	Effective Head	m	32.3
Number of Turbine & Generator		Unit	2
Annual Power Generation		MWh	9,020

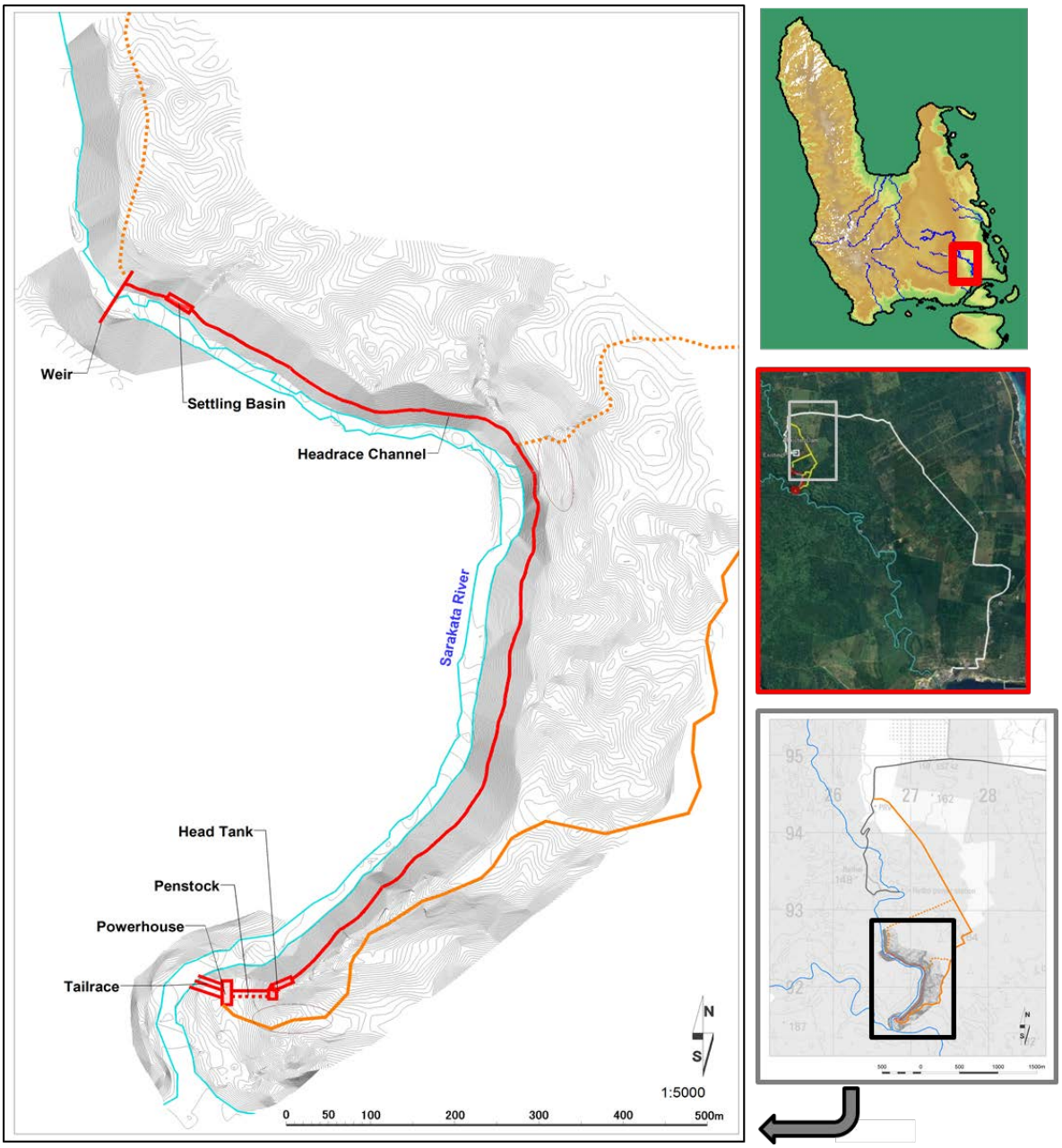


Figure 2.1-1 Project Layout

2.2 Outline Design of the Requested Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Basic Design Concept

(1) Policy for Scope of Works

The existing Sarakata River Hydroelectric power plant which was constructed as Japan Grant Aid Project has been the major power supply in Santo Island. However, in the recent years, the diesel power plant has been operated increasingly, due to the growing power demand. The Government of Vanuatu aims for a high target, i.e. 100% of renewable energy generation by 2030. Further introduction of renewable energy will reduce the dependence and consumption of imported fuel and will lower electric bill and reduce the effects of global warming. The Government of Vanuatu has strongly requested support for the further use of renewable energy, especially for the enhancement of hydroelectric power generation facilities.

This project contributes to increasing the renewable energy rate of Santo Island in Vanuatu. In addition, it is carried out as part of Hybrid Island concept

The weir is to be constructed approximately one (1) km downstream at the outlet of the existing Sarakata River Hydroelectric power plant. The intake water flows into an open channel, and then into a head tank and pressure steel pipe and finally supplied to the hydraulic turbine. Scope of Grant aid project covers construction of hydroelectric power generation facilities, procurement and installation of hydro-mechanical equipment, construction of 20kV transmission line and installation of additional transformer at the existing substation.

Through site investigation it was observed that the route of access road to the power plant passes through a steep V-shape valley, and excavation works have to be carried out at areas of high altitude with steep slopes. Considering the difficulty of works and past records, it has been determined that there are high risks of delay and construction failure, in case the Vanuatu side is responsible for the construction of access roads. Based on this, JICA Study Team discussed about this matter with DOE and confirmed that the DOE would like to include the construction of access road to the components of the grand aid project.

The following matters were confirmed and concluded based on discussion with DOE.

- In case the 1,000kW new hydroelectric power plant is connected to the existing 20 kV transmission line, the shortage of transmission capacity does not occur.

- Regarding the low voltage condition, it can be solved by adjusting the existing transformer and keeping it within the standard voltage.

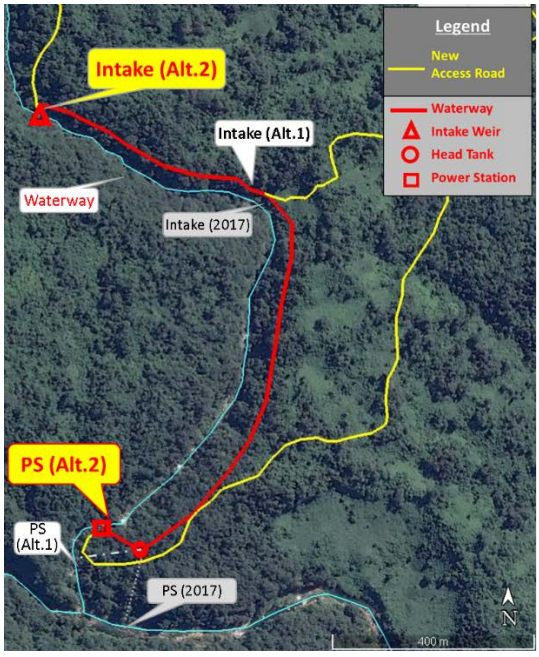
As a result of site investigation, it was confirmed that the capacity of the existing transformer at the existing Luganville substation shall be enhanced because the capacity of the transformer is not sufficient for the additional 1,000 kW new power plant. Therefore, enhancement of the substation has to be included to the components of Japan grant aid project.

(2) Policy for Site Identification

The JICA Study Team carried out site investigations and verified the planned locations of weir,

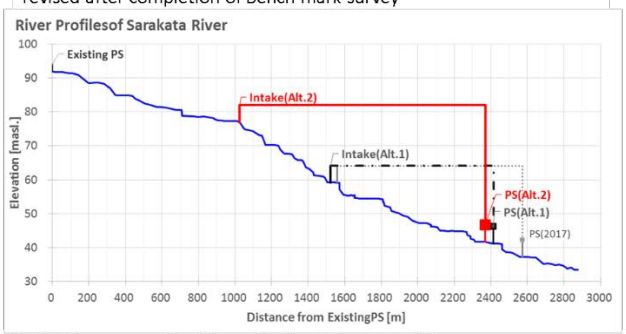
intake, open channel route, power plant determined by the Data collection survey of Power Sector in Espiritu Santo in the Republic of Vanuatu. As a result of site investigations, the location of planning weir is shifted by about 500 m to the upstream, because there is steep riverbed slope in the upstream of the existing weir site. The location of the power plant is shifted by about 100 m to the upstream, where there is plane area at the upstream of the confluence. Original location of the weir was in the downstream of the confluence. In this result, gross head between the intake WL and outlet WL is 35m and it was 15m in the original plan.

In this project the intake weir is planned to be constructed at about one (1) km downstream of the outlet of the existing Sarakata hydropower station, taking power discharge from the intake, and introducing water to the hydraulic turbine at the new power station via a headrace channel, a head tank and a penstock.



Case	point	Elevation [masl.]		Remarks
Original-2017	Intake(2017)	64.1	Gross Head	Penstock passes
	PS(2017)	42.3	**21.9 m**	valleys
Alternative-1	Intake(Alt-1)	64.2	Gross Head	Penstock slope is
	PS(Alt-1)	46.2	**18.1 m**	gentle
Alternative-2	Intake(Alt-2)	82.0	Gross Head	Larger head can be
	PS(Alt-2)	46.7	**35.2 m**	available

These values are tentative and absolute values of elevation will be revised after completion of Bench mark survey



Preliminary result of Longitudinal river profile survey
(The absolute values of elevation will be revised after completion of Bench mark survey)

Figure 2.2-1 Project location of New Hydroelectric power project

(3) Policy for Scale of Facilities

According to the results of "Data Collection Survey on Power Sector in Espiritu Santo", the optimum plan is to construct an 800kW run-of-river type hydroelectric power plant in the downstream of the existing Sarakata River hydroelectric power plant. Based on the results of topographic survey, the basic layout determine during the Data Collection Survey was reviewed. The alternative scheme to secure around 35m gross head was confirmed.

Also, river rating curve was reviewed based on river discharge measurement, and the preliminary generation plan of the alternative scheme was examined. On examination, it was concluded that it is possible to develop an 800 to 1,000 kW scale hydroelectric power plant as proposed in the original plan. It was confirmed that after the completion of 1,000kW scale hydroelectric power plant, it is possible to develop an additional 500kW class scale.

(4) Policy for Seismic Design

Seismic design should be done in structural design, because Vanuatu is an earthquake prone

area. Since there are no design standards for civil design/architecture, seismic design will be based on the Japanese design standards as for existing structures. Therefore, the design horizontal seismic intensity (kh) is set to 0.15, and the standard shear coefficient (Co) is set to 0.2 for architectural structures.

The maximum instantaneous wind speed of the cyclone has been observed to be approximately 70 m/s. The design wind speed depends on the topographical characteristics and facility elevation. Therefore, the design wind speed of the power station and transmission lines should be considered during the design of structure.

2.2.1.2 Brief Summary on Construction/Procurement Conditions

(1) Land acquisition

Facilities to be constructed in this project are mostly located on the left bank of the Sarakata River where Plantation Russet Vanuatu (PRV) has run a plantation farm and ranch under a long-term lease agreement with the customary land owners. Only the intake weir extends to the right bank, which is also registered as a customary land. The Vanuatu government will possess lands for the hydroelectric power plants including a powerhouse, intake weir, headrace channel, head tank and a part of access road through the land acquisition procedure. Lands for the access road and transmission line in the plantation farm and ranch will be acquired under an easement agreement without possessing them.

(2) Disposal area for surplus soil

A disposal area for surplus soil is needed near the project site. The area is basically used without land acquisition, to encourage the reuse of surplus soil. In this project, however, there is a possibility that some surplus soil may not be reused. This is because, a large amount of surplus soil is expected and some of it will be left at the disposal area after the project. In some cases, the land user i.e. PRV insists the government to acquire the land for disposal area. Therefore concerned parties including PRV, DOE and DOL should have a consultation meeting to deal with the issue of disposal area.

(3) Procurement of local resources

1) Labor

Skilled workers such as concrete workers, form workers and machinery operators should be employed in Luganville or Port Vila, the capital of Vanuatu, because there are no skilled labors around the project site. The project does not include special works, so the works can be carried out by the local workers without the need to bring skilled workers from Japan or other countries.

2) Construction machinery

Not only do the construction companies have a limited number of equipment, there is also no leasing or rental company to rent/lease construction equipment in Vanuatu. It is necessary to considered importing construction machinery from Japan or other countries, if it is not possible to procure it locally.

3) Construction materials

Though common construction materials except for aggregate are not locally manufactured, it is possible to procure imported materials from Austria, Fiji, etc. in Vanuatu. Local coral aggregate is widely used in Vanuatu. However it is necessary to carefully consider the use of this material, because it has been proved to be light and friable for certain structures.

4) Procurement of equipment

Equipment for "Hydroelectric power plant", "Substation" and "Transmission Line" are necessary for the project. These required equipment are not produced in Vanuatu and it is possible to procure from Japan or a Third country. There is an existing "Sarakata" hydroelectric power plant in Santo Island and the operators of the existing power plant will also manage and maintain the new hydroelectric power plant. There is a possibility of increasing operators' burden if the operation of equipment is totally different from the existing one. In order to prevent this situation, selection of equipment shall be considered from the perspective of operability. In addition, procurement of substation and transmission line shall be considered from the perspective of operation and maintenance.

2.2.1.3 Brief Summary on Use of Local Contractors

There are local construction companies in Luganville and Port Vila, the capital of Vanuatu, and these companies have mainly worked on building and/or road constructions. These local companies do not have experience in constructing a hydropower plant, and it is deemed that they do not have adequate ability to manage the works of this project as a subcontractor. Considering this circumstance, Japanese contractors should directly employ and manage local workers instead of subcontracting.

2.2.1.4 Brief Summary on Operation and Maintenance

UNELCO had been supplying power in the Luganville concession area for 20 years from 1990 until 2010 under the concession contract. Through the bidding for selection of a power company, the Vanuatu Utilities and Infrastructure Limited (VUI), a subsidiary of Pernix Group, Inc. in the United States made a successful bid. And VUI has been supplying power under a vertical integration conformation such as generation, distribution, collection of electricity bill since January 2011 (official contract signing was done on June 2011). At the time of transfer of business, the operators and maintenance staff who had worked at the existing Sarakata River power plant were employed by VUI. Turbine and generator of No.1 and No.2 was commissioned in 1995 and No.3 in 2009, therefore the former has been used for around 25 years and the latter for around 10 years. All equipment is operating without serious problems under a 3-shift operation and maintenance system. However, overhaul of turbines and generators has not yet been done and the major parts, whose service life has expired, has not yet been replaced with new ones. So, it can be hardly said that the generation facilities are in a sound condition.

The power output adjustment of hydroelectric power plant and diesel power plants is done manually by operators using radio transmission.

The new hydroelectric power plant in the downstream of the existing power plant will adopt automatic operation system and will be operated by means of remote control system from the existing power plant. Operation and maintenance, countermeasures in case of accidents, repair

of damaged facilities and so on have to be carried out by the existing operators and maintenance staff. The control equipment of the existing plant is not replaced and there is no change to the current operation method.

Therefore, it is necessary to guide the operators and maintenance staff in matters concerning operation and maintenance, inspection and also provide On-the-Job Training regarding countermeasures in case of accidents, repair of damaged facilities. More sustainable management can be planned by providing operation and maintenance manual and introducing preventive maintenance concept of generating equipment.

2.2.1.5 Brief Summary on Level of Facility/Equipment

(1) Facility

Civil and building structures are designed in conformity with Japanese standards so as to ensure adequate stability, structural mechanics and durability. An access road is laid out to get across a steep slope area. Therefore, a large-scale excavation is unavoidable. The alignment and width of the road should be determined so as to reduce the earth volume as much as possible without impairing the function. It is preferred to import electrical and mechanical materials for building works from Japan or other countries, since it is not possible to procure the required quality and quantity of materials, as per the schedule in Vanuatu. To ensure quality and economic efficiency, the materials shall conform to Japanese standards such as JIS or worldwide-recognized standards.

(2) Equipment

Procurement is organized in accordance with the standard/code of manufactured country such as New Zealand, Australia, Europe and Japan where the equipment is purchased from, as Vanuatu does not have any original standards/codes for the electrical and power sector. Equipment of the existing Sarakata Hydroelectric Power Plant was procured according to JIS/JEC/JEM. Therefore, equipment in the project shall conform to JIS/JEC/JEM in order to ensure quality and economic efficiency.

It is necessary to keep operators to a minimum from the perspective of sustainable operation and maintenance of hydroelectric power stations in Santo Island. In order to achieve such an operation mechanism, a remote operation system is planned for the new Sarakata power plant enabling it to be operated from the existing power plant and is required to secure the safety of power plant's operation. Natural disasters such as earthquakes, hurricanes and so on, occur frequently in Santo Island. In order to build a resilient infrastructure, designed external forces such as wind speed and intensity of earthquake are reviewed using the latest data.

2.2.1.6 Brief Summary on Construction / Procurement

(1) Construction

Headrace channel and access roads are constructed in and around a deep V-shaped valley and therefore, a large volume of surplus soil, estimated to be more than 300,000 m^3, will be dug out from the construction site. Therefore it is necessary to have an economical construction plan with a short construction period. However, it is not possible to shorten the construction period by increasing the number of construction machinery at a given time, as there is no enough space on the steep slope. Therefore, a feasible construction plan should be made with due

considerations to economic efficiency, safety and local procurement circumstances.

(2) Procurement of Equipment

There are no critical matters in the procurement process of equipment for the project, since headrace channel and access road will require long construction periods. The processes involved in the procurement of equipment are: purchase order, manufacturing, delivery and erection at site. In the context of above, the followings basic policies are laid out for procurement of equipment in the project;

1) Program outline

The most economical program outline is developed that can be carried out effectively within the construction period with minimal engineers and workers with due regard to safety.

2) Contractor and Project Management

Vanuatu does not have contractors to carry out equipment procurement and process, quality and safety management appropriately. The Contractor should assign a site manager, who is in charge of managing all site activities related to equipment, and technical supervisors, who are dispatched from the manufacturers' company and in charge of installation, commissioning and training. The Contractor should consider involving the power plants operators in works during the stage of pre-commissioning/ commissioning, in order to smoothly the transfer operation and maintenance work after COD.

3) Local operators and labors

Basically, general labors who are engaged during the erection of equipment will be hired from local community.

2.2.1.7 Concept on Environmental and Social Considerations

There are no residential areas on this Project site and no involuntary resettlement will occur. In addition, there are no areas of protection and cultural heritage. Therefore, no serious environmental impact will be expected. However, since large-scale earthworks will be carried out and it will be necessary to acquire the land, the following two points will be considered in the design policy.

(1) Countermeasures in Construction Phase

Large-scale excavation will be carried out, due to the construction of headrace channel and access roads in steep valleys, and this is likely to have a negative environmental impact (causing turbid water) mainly on the water quality. Although it was confirmed that the water of Sarakata River is not used around the Project site, however, since the river flows to Luganville, the countermeasures for turbid water during the construction will be considered. The countermeasures include the treatment of turbid water by constructing temporary sand basins and cofferdam.

(2) Countermeasures for Land Acquisition

Land acquisition of approximately 350,000 m^2 is expected for this project. Most of the land

belongs to PRV, who are running the plantation, but some parts include customary land. In order to proceed with the Project smoothly, it is necessary to carry out appropriate land acquisition procedures and provide compensations in consultation with the land owners and plantation owners. Although stakeholder meeting has been already held in this Project, all stakeholders will continue to communicate at the project implementation stage.

2.2.2 Basic Plan (Construction Plan/ Equipment Plan)

2.2.2.1 Precondition of the Plan

(1) Present Balance of power demand and supply

Variation of peak demand and annual sale of generated energy from 1994 to 2017 are shown in the following figure. Sarakata river hydroelectric power plant 1st stage and 2nd stage 600 kW (300 kW x 2 units) was commissioned in 1994 and 1995 and in 2009 an additional 600 kW was commissioned. At present, the total hydroelectric power is 1,200 kW. Installed capacity of each power source in Luganville grid are 1,200 kW hydropower, 2,600 kW diesel power and 40 kW solar power. The maximum power output is 1,923 kW in 2016 and the annual sales generating energy is about 9,000 MWh. The power demand is increasing year by year. In the last 10 years, the annual rate of increase of peak demand is 3.3 %/year, and rate of increase of annual sales generating energy is 3.7 %.

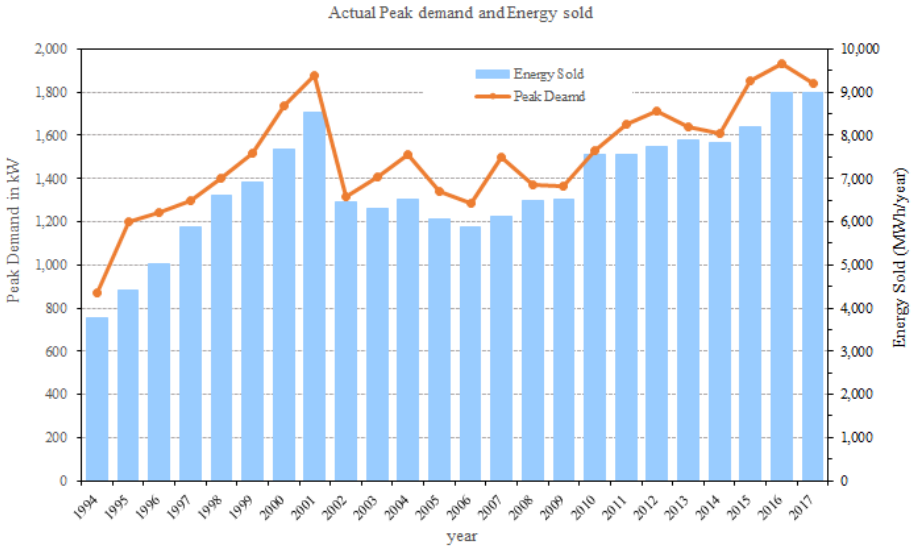


Figure 2.2-2 Peak power demand and Annual sales generated energy (1994 to 2017)

In connection with increasing the power demand, the rate of hydropower to the total generated energy was more than 80 %, but less than 70 % recently. In the dry year 2016, the rate was lowered to 50 %. Also, the power supplied by hydroelectric power is not sufficient and it has led to the increased use of diesel power plants. Therefore this scheme was proposed in order to reduce the dependency of imported fuel and lower the electricity bill.

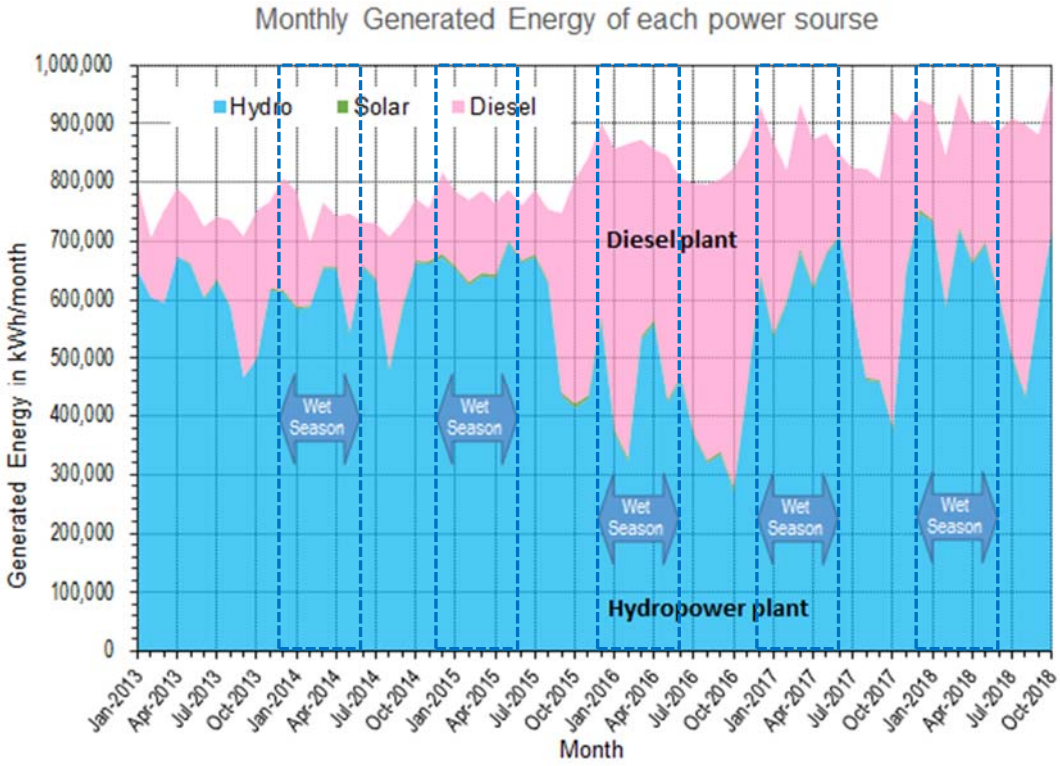
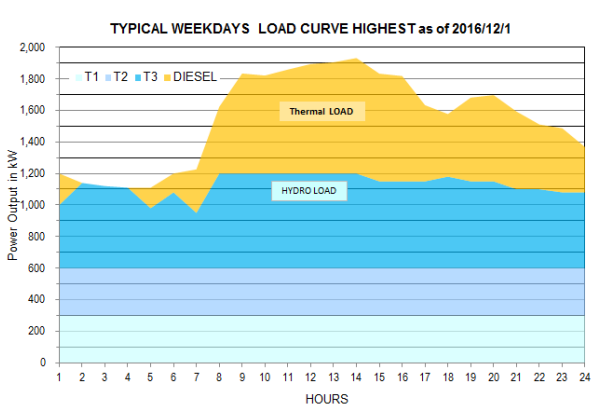


Figure 2.2-3 Monthly generated energy of each power source (Jan. 2013 ~ Oct. 2018)

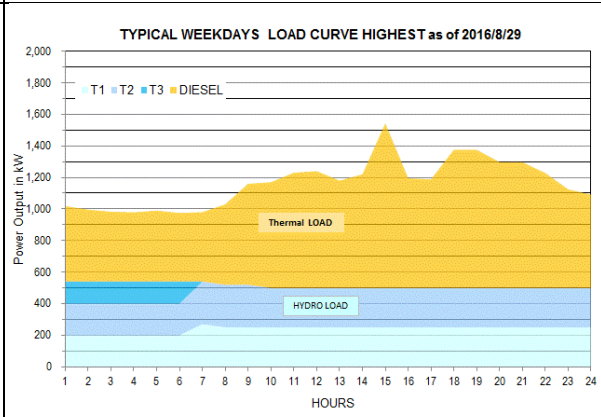
Daily load curve of Luganville grid has peaks of daytime and nighttime due to lighting. In the wet season with abundant river flow, it is possible to operate the hydroelectric power plant at the maximum output of 1,200 kW, but in the dry season with decreasing flow, the power output is lowered to around half of the maximum output i.e. 600 kW.

(1) daily load curve in the wet season

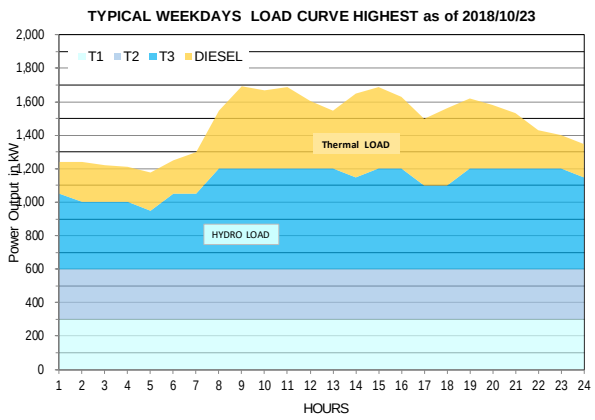


As of December 1, 2016 (Wet season)

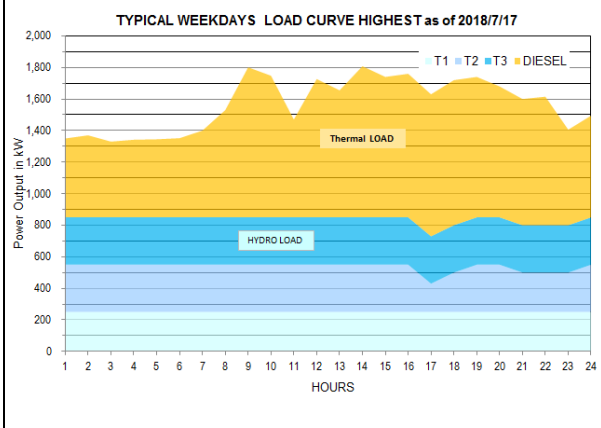
(2) daily load curve in the dry season



As of October August 29, 2016 (Dry season)



As of October 23, 2018 (Wet season)



As of August 29, 2018 (Dry season)

Figure 2.2-4 Typical daily load curve in the wet and dry seasons of the Luganville grid

(2) Operation conditions of diesel power plants

Monthly consumption of diesel oil and its expenses from January 2011 to October 2018 are shown in the following figure. In the dry year of 2016, the operation rate of hydroelectric power plant became low, leading to a high operation rate of diesel power plants, and the expense of diesel oil also increased due to this. The oil consumption has shown an upward trend after 2017.

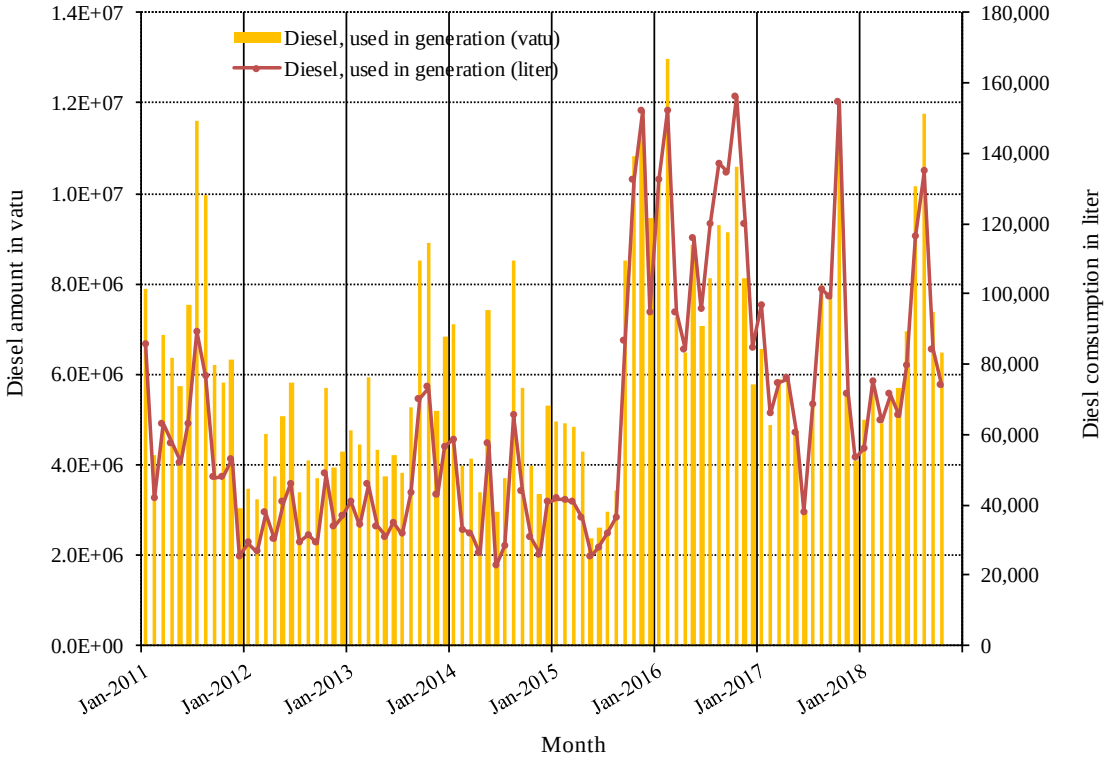


Figure 2.2-5 Monthly consumption of diesel generation oil and its expense (Jan. 2011 ~ Oct. 2018)

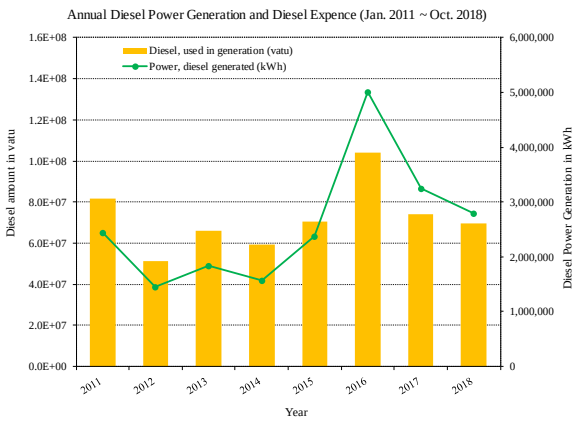


Figure 2.2-6 Annual expense of diesel generation oil (Jan. 2011 ~ Oct. 2018)

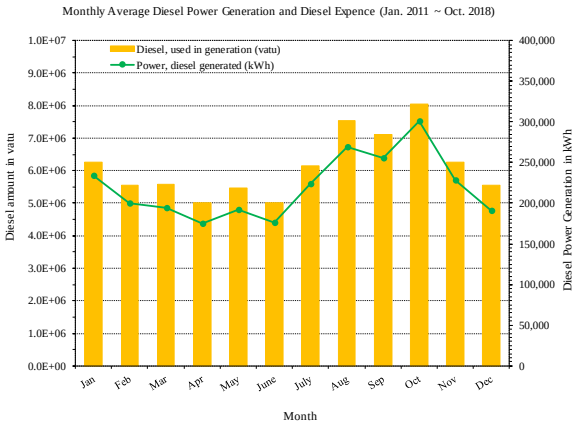


Figure 2.2-7 Monthly expenses of diesel generation oil (Jan. 2011 ~ Oct. 2018)

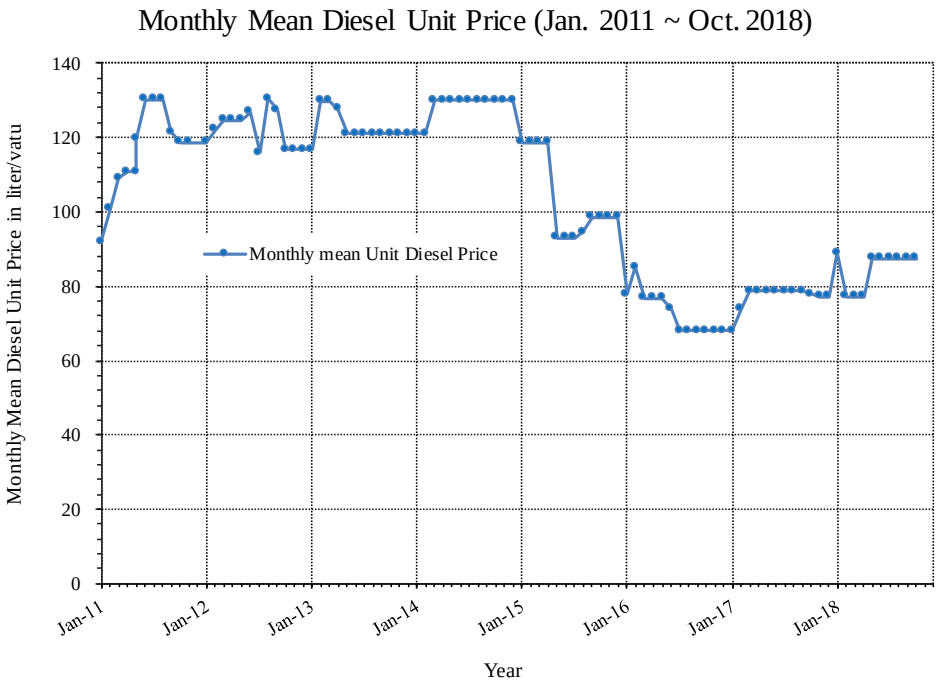


Figure 2.2-8 Monthly variations of the price of diesel generation oil (Jan. 2011 ~ Oct. 2018)

(3) Power Demand Forecast

In the last ten (10) years (2008~2017), peak power demand and annual sales generated energy have increased at the rate of 3.3 % and 3.7% respectively. The power demand forecast up to 2030 was conducted using these rates. Peak demand of 2030 is assumed to be 146 % more than the existing one, i.e. around 2,800 kW, and the annual sales of generated energy is assumed to be 160 % more than existing one, i.e. around 14,400 kWh/year. Installed capacity of the existing Sarakata river Hydroelectric power plant is 1,200 kW and a new 1,000 kW scale plant will be constructed as per the plan. Estimated peak demand of 2023 will surpass the total capacity of 2,200 kW. Power demand is increasing year by year, it is necessary to reduce the consumption of diesel generated power.

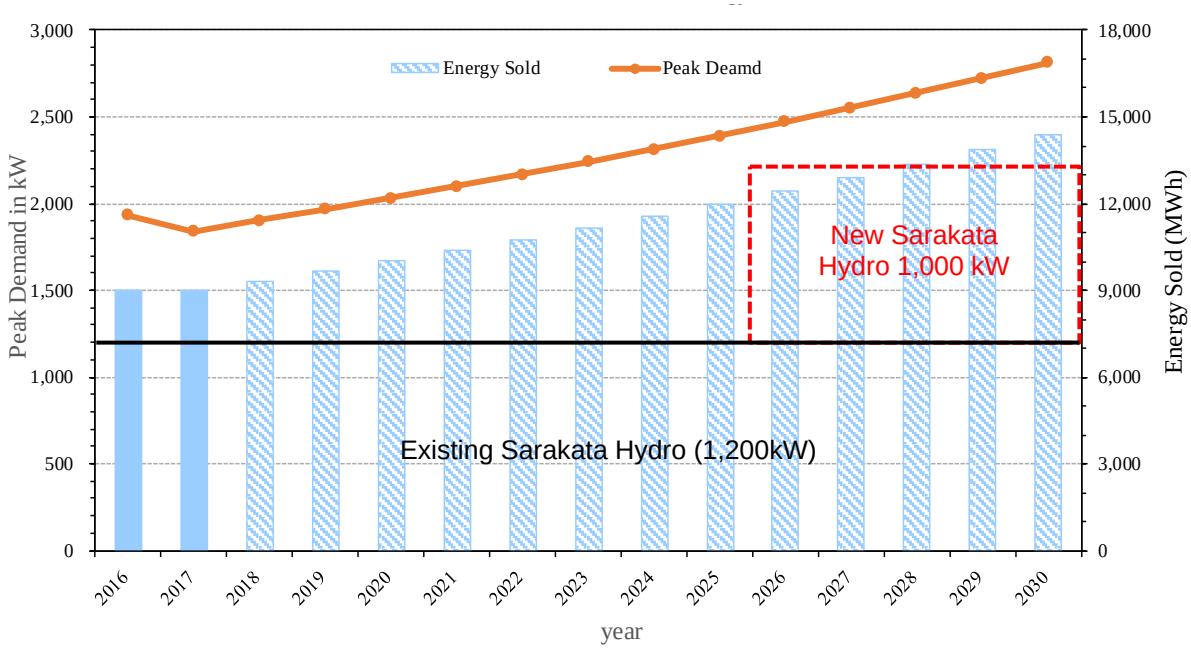


Figure 2.2-9 Forecast of Peak demand and Sales generated energy

2.2.2.2 Power Generation Planning

(1) Power generation plan

1) River flow duration curve

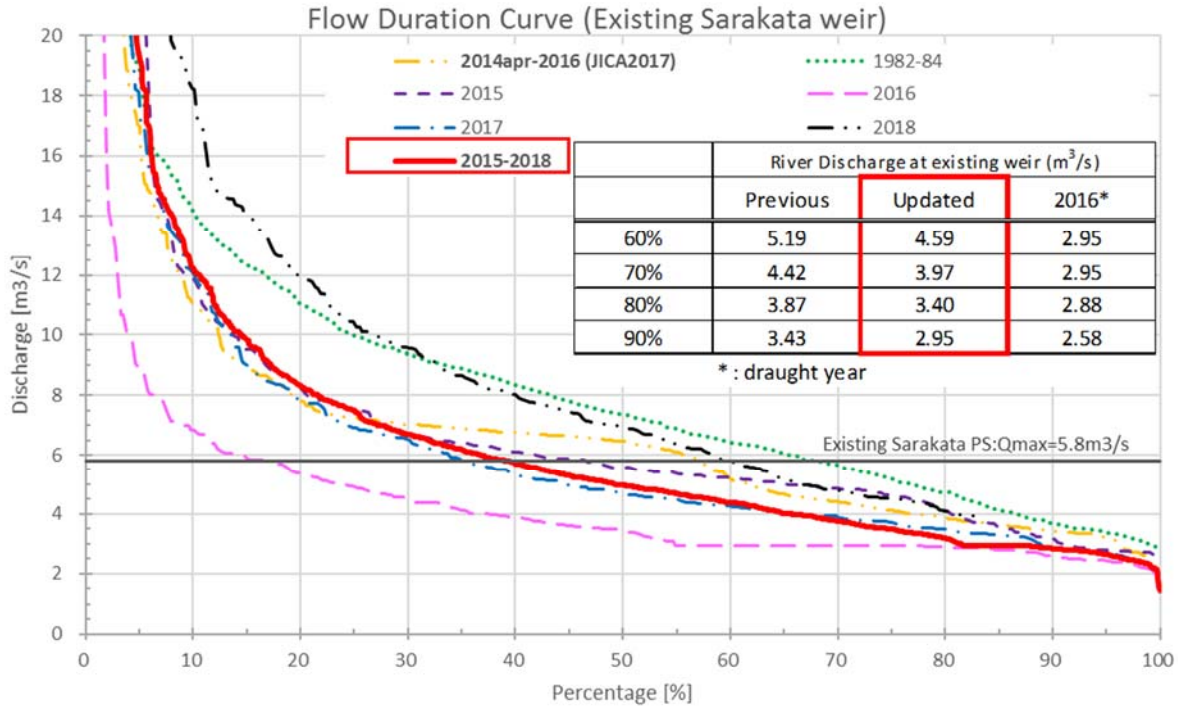
A flow duration curve based on long-term river discharge measurement is very important to carry out the power generation plan of run-of-river type hydroelectric power. The following flow duration curves are shown in the below figure.

a) Original curve used for the existing Sarakata river hydroelectric power project and additional plan

b) Revised curve used in the Data Collection Survey of Power Sector in Espiritu Santo

c) Updated curve applied to this scheme using the river flow based on the operation records from 2015 to 2018

The flow duration curve updated for this scheme is not adjusted by the compensation of monthly rainfall data, which applied to the flow duration curve used in Data Collection Survey of Power Sector in Espiritu Santo. Therefore, the river flow is evaluated to be less than the other curves. This scheme uses the updated one.



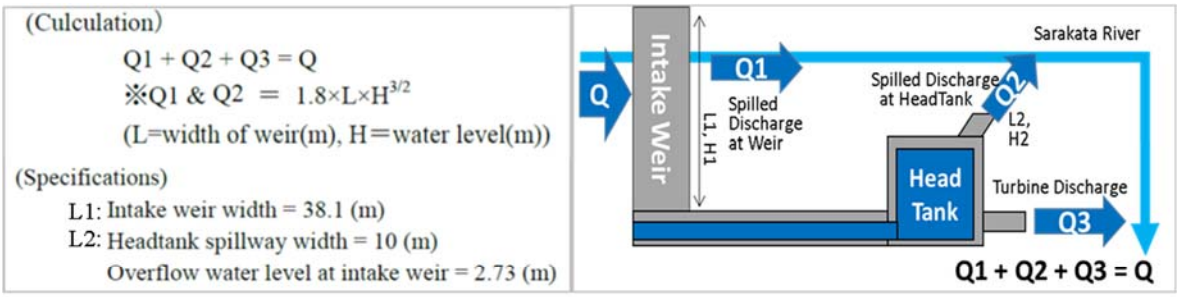
	River Discharge at existing weir (m^3/s)		
	Previous	Updated	2016*
60%	5.19	4.59	2.95
70%	4.42	3.97	2.95
80%	3.87	3.40	2.88
90%	3.43	2.95	2.58

* : draught year

Figure 2.2-10 Flow duration curve (Sarakata River)

2) River flow calculation base on operation records

The river flow based on the operation records is calculated by the following method, which is as same as one used in Data Collection Survey in 2017.



Q1: Spilled discharge at Weir

Q1 = 1.8 x L1 x H1 $^{3/2}$, H1 = WL. – 2.73, WL. Water level at Intake weir
WL. < 2.73 (m) → H1=0.0 → Q1 = 1.8x 38.1 x 0 $^{3/2}$ = 0.0 m^3/s

Q2: Spilled discharge at Head Tank

Q1 = 1.8 x L2 x H2 $^{3/2}$, H=0.02 (m) (information from VUI) → Q1 = 1.8x 10x 0.02 $^{3/2}$ = 0.051 m^3/s

Q3: Turbine discharge

$Q3_{max.}$ = 1.45 x 2 + 2.9 = 5.8 m^3/s (←No.1, No.2: 1.45 m^3/s, No.3: 2.9 m^3/s)
Turbine discharge for each turbine (No.1,2,3) is calculated by maximum turbine discharge (m^3/s), power generation record (kW), and effective head (m)

Source：Data collection survey, 2017

Figure 2.2-11 Diagram of river flow conversion

3) Calculation of maximum power output and generated energy

Power output and annual available generated energy for this scheme are calculated using the following formula for power discharge between 4m^3/sec and 7m^3/sec. The effective

head is 32.2m and the combined efficiency of turbine and generator varies depending on the power discharge.

$$P = 9.8 \times Qp \times He \times \eta_{tg}$$

Where, P : Power output (kW)
Qp : Power discharge (m^3/sec)
He : effective head (=32.3m)
η_{tg} : efficiency of turbine and generator (=0.85)

$$E = 8{,}760 \times P \times FUF$$

Where, E : Annual Available Generated Energy (kWh/year)
FUF : Flow utilization factor (%)

In case the power discharge is more than 4.0m^3/sec, the power output become more than 1,000kW. Flow utilization factor (FUF) is also high and more than 90%, and in the dry season with less river flow, it is expected that sufficient energy will be generated. In fact FUF was around 85% in the dry year of 2016.

Table 2.2-1 Power output, annual available generated energy and Flow utilization factor of various power discharge (2015~2018)

Qp [m^3/sec]	Pmax*1 [kW]	Energy [MWh/year]	increment [%]	FUF [%]
4.0	1,076 (970)	8,763	0.0%	92.9%
4.5	1,211 (1,100)	9,481	8.2%	89.4%
5.0	1,345(1,220)	10,095	6.5%	85.7%
5.5	1,480 (1,340)	10,604	5.0%	81.8%
6.0	1,614 (1,460)	11,029	4.0%	78.0%
6.5	1,749 (1,580)	11,377	3.1%	74.3%
7.0	1,883 (1,710)	11,663	2.5%	70.7%

Note : *1: ( ) installed capacity, Pmax has 10% margin

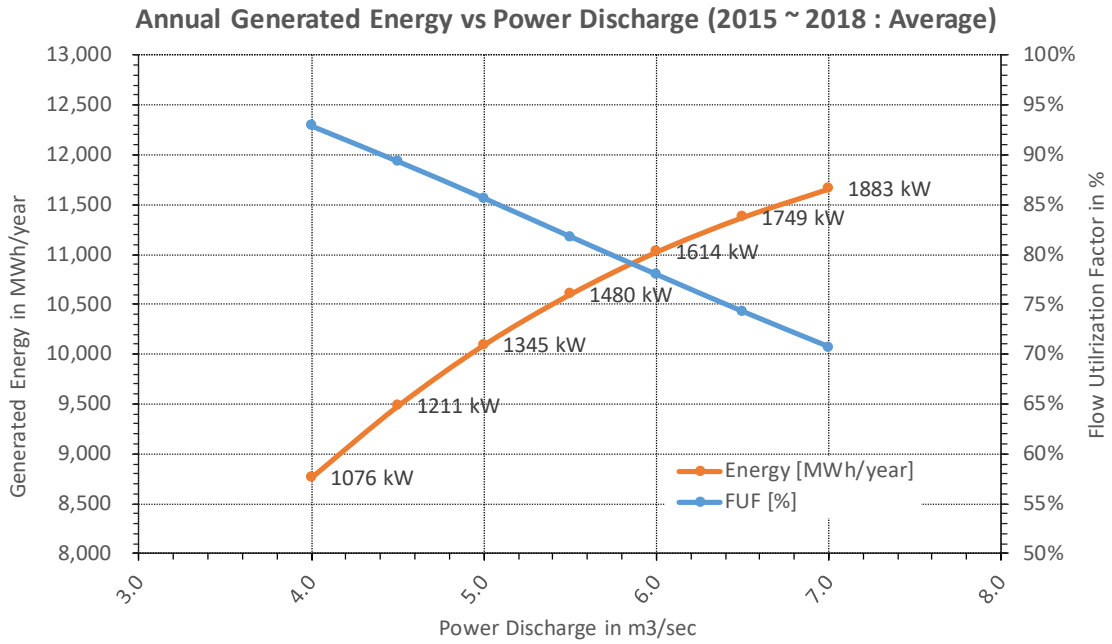


Figure 2.2-12 Power output, annual available generated energy and Flow utilization factor of various power discharge (2015~2018)

Table 2.2-2 Power output, annual available generated energy and Flow utilization factor of various power discharge (drought year of 2016)

Qp [m^3/sec]	Pmax*1 [kW]	Energy [MWh/year]	increment [%]	FUF [%]
4.0	1,076 (970)	8,089	0.0%	85.8%
4.5	1,211 (1,100)	8,433	4.2%	79.5%
5.0	1,345(1,220)	8,677	2.9%	73.6%
5.5	1,480 (1,340)	8,836	1.8%	68.2%
6.0	1,614 (1,460)	8,952	1.3%	63.3%
6.5	1,749 (1,580)	8,998	0.5%	58.7%
7.0	1,883 (1,710)	9,018	0.2%	54.7%

Note : *1: ( ) installed capacity, Pmax has 10% margin

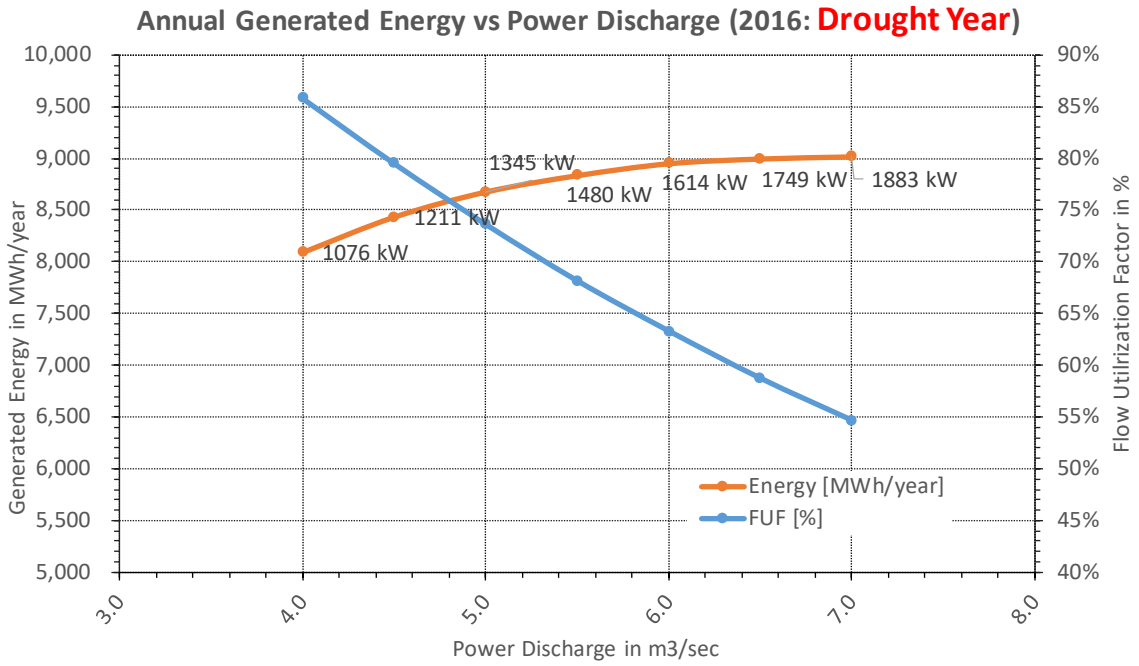


Figure 2.2-13 Power output, annual available generated energy and Flow utilization factor of various power discharge (drought year of 2016)

(2) Expansion Possibility

The power discharge of a 1,000kW hydroelectric power scheme is assumed to be around 4m^3/sec. On the other hand, the total power discharge of the existing Sarakata river hydroelectric power plant (1,200kW for 3 units) is 5.8m^3/sec and the additional power discharge of additional Unit No.4 is 1.45m^3/sec.

Based on the above condition, the expansion scheme of the new plant is sure to be more economical than the one of the existing plant. Therefore, the possibility of the expansion scheme is studied. In case the additional power discharge is 2.0m^3/sec, the power output is around 500kW and the annual available generated energy is about 2,100GWh, which is an addition of around 22% generated energy under the new power plant scheme. In the drought year of 2016, annual available generated energy is about 770GWh, which is an addition of around 10% generated energy under the new power plant scheme

Table 2.2-3 Power output, annual available generated energy and Flow utilization factor of various power discharge by the expansion scheme (2015~2018: average)

Qp [m^3/sec]	P [kW]	Energy increment		FUF*1 [%]
		[MWh/year]	[%]	
1.5	419	1,714	17.4%	81.8%
2.0	558	2,118	21.5%	78.0%
2.5	698	2,458	25.0%	74.3%

Remarks: *1: FUF after the construction of expansion scheme

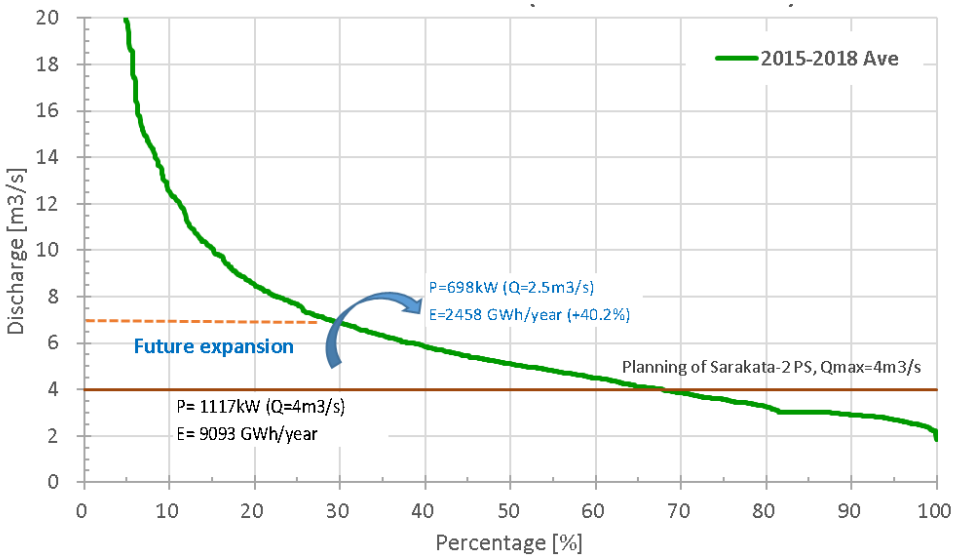


Figure 2.2-14 Power discharge and annual available generated energy of 500 kW scale expansion plan (2015~2018)

Table 2.2-4 Power output, annual available generated energy and Flow utilization factor of various power discharge by the expansion scheme (2016: Drought Year)

Qp [m^3/sec]	P [kW]	Energy increment		FUF*1 [%]
		[MWh/year]	[%]	
1.5	419	813	9.7%	68.2%
2.0	558	957	11.4%	63.3%
2.5	698	1,069	12.7%	58.7%

Remarks: *1: FUF after the construction of expansion scheme

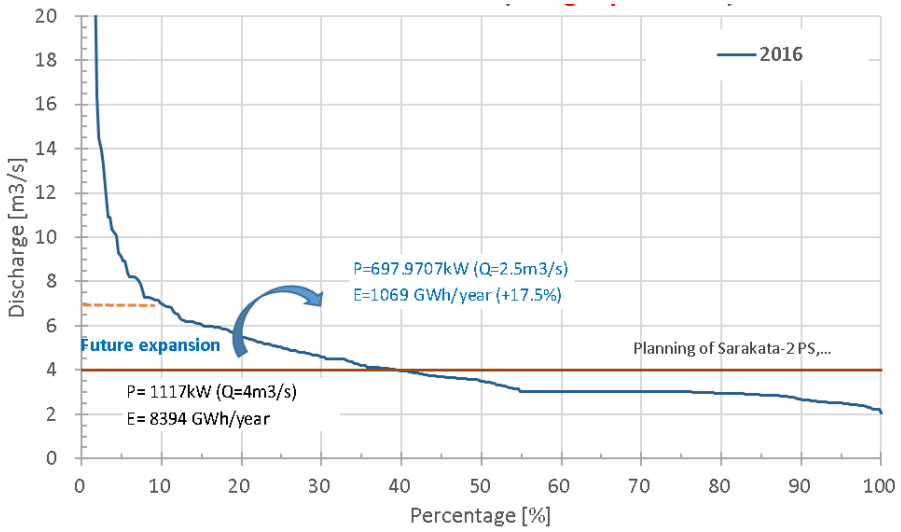


Figure 2.2-15 Power discharge and annual available generated energy of 500 kW scale expansion plan (drought year of 2016)

(3) Study on the work coverage of expansion scheme during construction of a new plant

On examining the expansion scheme, it is determined that it is possible to implement a 500kW scale expansion plan. Construction coverage of the expansion plan (future Unit No.3 of 500kW) during the construction of a new plant is determined considering the following aspects.

(a) Minimize the operation stoppage duration of the new power plant by including construction of the expansion scheme.

(b) Shorten the construction schedule of expansion scheme by including construction of the expansion scheme.

(c) Largely reduce the construction cost incurred for the expansion scheme by including construction of the expansion scheme.

(d) Not necessary to carry out repair and replacement works caused by deterioration in the expansion scheme, even though the construction of the expansion scheme is conducted earlier.

(e) Design changes of expansion scheme will not occur, even though the construction of the expansion scheme is conducted earlier.

Table 2.2-5 Work Coverage of Expansion Scheme during Construction of a New Hydropower Plant

Civil facility	Work coverage included the new construction	Work coverage during the expansion construction	(a)	(b)	(c)	(d)	(e)
Intake weir*1	The same works despite of expansion	No work is necessary during expansion	-	-	-	-	-
Intake	all works required for expansion	No work is necessary during expansion	○	○	○	○	○
Settling basin	all works required for expansion	No work is necessary during expansion	○	○	○	○	○
Headrace (Open channel)	all works required for expansion	No work is necessary during expansion	○	○	○	○	○
Head tank	all works required for expansion	No work is necessary during expansion	○	○	○	○	○
Spillway	all works required for expansion	No work is necessary during expansion	○	○	○	○	○
Penstock	Penstock required for the expansion of No.3 Unit is not installed.	Penstock required for the expansion of No.3 Unit is necessary		○			○
Foundation of power house	Foundation works required for expansion of No.3 Unit is constructed	No foundation work during expansion is necessary	○	○	○	○	○
Power house building	Space of powerhouse building required for the expansion of No.3 Unit is not constructed.	Works for additional space required for the expansion of No.3 Unit is necessary.					○
Site preparation of power house	all works required for expansion	No work is necessary during expansion	○	○	○	○	○
Tailrace and Outlet	No work of tailrace facilities for expansion of No.3 Unit is constructed.	All works of tailrace facilities for the expansion of No.3 Unit is constructed.		○			○
Transmission line	No work required for additional capacity of expansion is done.	Works required for additional capacity of expansion is necessary.		○			
Substation facility	No work required for additional capacity of expansion is done.	All works of substation facilities for the expansion is necessary.		○			
Turbine and generator		Procurement and installation of the expansion of No.3 unit is necessary		○			
Control and protection equipment		Procurement and installation for the expansion of No.3 unit is necessary		○			

*1: dimension of intake weir is not changed in case of expansion

As given in the above table, it is necessary to stop generation of unit No.1 and 2 for the constructing major structures such as settling basin, headrace open channel, head tank etc. for the No.3 unit expansion. Also re-excavating of slope and augment work etc. are required in order to increase the structure capacity for expansion and it leads to a high construction cost for expansion. Therefore, some works for expansion are covered in this plan.

On the other hand, construction of penstock, power house building, tailrace, outlet etc. for unit No.3 expansion which are not necessary to stop the generation, and also expansion works for unit No.3 which have effect in reducing the construction cost of expansion are not included in this work plan.

Transmission line and substation facilities which have small effect in reducing the construction cost are not included in this work plan, too.

(4) Study on Optimum Scale Hydropower Development

Preliminary estimated construction costs were calculated for various power discharges from $4m^3$/sec to $7m^3$/sec under the following conditions and unit construction cost per kWh for each power discharge was compared;

- Layout of civil facilities is not changed for each case.
- Scale of intake weir is not changed for each case.
- Access road is the same for each case.
- Number of turbines is decided so that installed capacity of one (1) unit does not exceed 600kW.
- The existing 1,500kVA transformer installed at Luganville substation is replaced to a new 3,000kVA one. In case that installed capacity of a new hydropower plant is larger than 1,300kW, a new transformer having larger capacity is required.
- Voltage drop and shortage of capacity of the existing 20kV transmission line connected between the Sarakata river hydroelectric power plant and Luganville substation does not occur after interconnection of a new hydropower plant. However, it is recommended to construct additional transmission line in order to improve reliability of power supply.
- The construction cost excludes construction supervision fee and soft component cost of the Consultant.

In case of no construction of additional 20kV transmission line, unit construction cost per kWh of 1,100kW scale plan with power discharge of $4.5m^3$/sec is the cheapest. 1,000kW scale plan with $4.2m^3$/sec as the target is selected in this study.

Table 2.2-6 Optimum Scale Hydropower Development Based on Unit Construction Cost per kWh

Unit: million yen

Case	1	2	3	4	5	6	7	8	9
Power discharge (m^3/sec)	4.0	4.2	4.5	5.0	5.5	6.0	6.3	6.5	7.0
Effective head (m)	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3	32.3
Max. Power Output (kW)	1,076	1,130	1,211	1,345	1,480	1,614	1,695	1,749	1,883
Installed capacity (kW) *1	970	1,020	1,100	1,220	1,340	1,460	1,540	1,580	1,710
Annual Generated energy (MWh/year)	8,763	9,061	9,481	10,095	10,604	11,029	11,244	11,377	11,663
Number of unit	2	2	2	3	3	3	3	3	3
Installed capacity per unit (kW)	485	510	550	407	447	487	513	527	570
Construction cost of Civil works	1,832.6	1,852.1	1,881.2	2,010.4	2,060.1	2,109.9	2,139.7	2,168.4	2,239.5
Construction cost of Architecture works	104.4	104.4	104.4	156.6	156.6	156.6	156.6	156.6	156.6
Purchase and Installation of Equipment	1,239.5	1,287.0	1,363.0	1,490.6	1,604.5	1,718.5	1,794.4	1,858.7	2,002.6
Additional 20kV T/L (L=20.5km)	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0	300.0
Total construction cost	3,176.5	3,243.5	3,348.6	3,657.6	3,821.3	3,985.0	4,090.8	4,183.7	4,398.7
Total construction cost（incl. 20kV T/L）	3,476.5	3,543.5	3,648.6	3,957.6	4,121.3	4,285.0	4,390.8	4,483.7	4,698.7
Construction cost per kWh	362.5	358.0	353.2	362.3	360.4	361.3	363.8	367.8	377.1
Construction cost per kWh (incl. 20kV T/L)	396.7	391.1	384.8	392.0	388.7	388.5	390.5	394.1	402.9
Note		without expansion					1500kW		

Note : *1: ( ) installed capacity, Pmax has 10% margin

In order to study on expansion plan, unit construction cost per kWh of cases of three (3) units of turbines and generators is compared. Unit construction cost per kWh of 1,540kW scale scheme with power discharge of 6.0m^3/sec is the cheapest among three (3) unit cases. Because Flow utilization factor of this case is 78% and high, the future expansion plan is valid from viewpoints of effective utilization of water resource. A new construction plan is two (2) units of 510 kW with total power discharge of 4.2m^3/sec, so the same scale unit of 510 kW is applied to expansion plan. The additional 20 kV transmission line to Luganville substation is to be constructed during the future expansion construction.

Based on study on work coverage of expansion scheme during construction of a new plant above mentioned, the preliminary construction costs for a new construction and expansion construction were estimated. The cost of expansion construction might increase largely because duration of the stoppage of the new hydropower plant under operation is longer due to expansion construction of waterway structures such as settling basin, headrace open channel and head tank, which is complicated. Therefore, it is recommendable to include the expansion construction of waterway structures in a new construction. The design policy of each facility is as follows;

- Intake weir, settling basin, headrace open channel, head tank and powerhouse foundation are designed with capacity required for future expansion plan. The expansion works for these structures are not necessary during expansion stage.
- Penstock for unit No.1 and No.2 and anchor blocks are designed and constructed. Penstock for unit No.3 and anchor blocks are to be constructed during expansion stage.
- Powerhouse foundation including unit No.3 pit is designed except maintenance space for all units is designed and constructed.
- Tailrace channels for unit No.1 and unit No.2 is designed and constructed. One for unit No.3 is to be constructed during expansion stage.
- Turbines, generators, control and protection equipment for unit No.1 and No.2 are purchased and installed. During expansion stage those for unit No.3 are to be purchased

and installed.

- Transmission line between the existing power plant and a new power plant is designed and constructed with capacity required for expansion plan. Therefore, no works during the expansion stage are necessary.
- The existing 1,500 kVA transformer at Luganville substation is replaced to a new 3,000 kVA one.
- The additional 20 kV transmission line to Luganville substation is to be constructed in order to improve the reliability of power supply.

Preliminary cost comparison between a new plant construction including the required expansion works and expansion construction is shown in the following table. More than 95% of total civil works including the required expansion works (installed capacity of 1,500 kW) is constructed during a new plant construction. The major expansion works include the purchase and installation of turbine, generator and control and protection equipment for unit No.3, the additional 20 kV transmission line to Luganville substation.

Table 2.2-7 Preliminary Estimated Construction Cost of New Construction and Expansion Construction

	New construction incl. some expansion (1,000 kW)	Expansion construction (500 kW)	Total construction (1,500 kW)	Ratio of new construction to total construction
Power discharge (m^3/sec)	4.2	2.1	6.3	
Effective head (m)	32.3	32.3	32.3	
Max. Power Output (kW)	1,130	565	1,695	
Installed capacity (kW) *1	1,020	510	1,540	
Annual Generated energy (MWh/year)	9,061	2,111	11,172	
Number of unit	2	1	3	
Installed capacity per unit (kW)	510	510	513	
Construction cost of Civil works	2,085.3	68.1	2,153.4	96.8%
Construction cost of Architecture works	104.4	52.2	156.6	66.7%
Purchase and Installation of Equipment	1,287.0	525.4	1,812.4	71.0%
Additional 20kV T/L (L=20.5km)	0.0	300.0	300.0	0.0%
Total preliminary construction cost	3,476.7	645.7	4,122.4	84.3%
Total preliminary construction cost incl. 20kV T/L	3,476.7	645.7	4,422.4	78.6%
Construction Cost per kWh	383.8	305.8	369.0	
Construction Cost per kWh incl. 20kV T/L	383.7	305.8	395.8	

Note : *1: ( ) installed capacity, Pmax has 10% margin, unit of cost: million yen

(5) Effective head and Maximum power output

1,000kW scale hydroelectric power plant is selected for this generation scheme based on Section 2.2.2.2 (1) Power Generation Plan. Effective head and maximum power output is as follows;

Head tank WL : 105.1m

Tailrace pit WL :	in operation 72.2 m (for Maximum power discharge) in stopping 71.5 m
Gross head :	32.9 m (for Maximum power discharge)
Maximum power discharge:	4.2 m^3/sec (total of 2 units)
Effective head :	32.3m
Maximum power output :	1,100 kW[*1](each unit 550 kW[*1], combined efficiency of turbine and generator η= 0.85) *1: considering around 10% margin for 1,000kW scale

Expansion plan is 500kW scale (1 unit, 550kW) with maximum power discharge of 2.1m^3/sec and effective head of 32.0m based on the result of Section 2.2.2.2 (2) Expansion Possibility.

Table 2.2-8 Calculation result of annual generated energy based on flow duration curve of each year (2015~2018)

	2015	2016	2017	2018		**Average (MWh/month)**
Jan	841	689	793	841		**791**
Feb	759	559	730	758		**702**
Mar	841	759	824	841		**816**
Apr	814	814	807	814		**812**
May	841	771	841	841		**823**
Jun	-	750	814	799		**787**
Jul	841	589	812	696		**734**
Aug	838	563	689	585		**669**
Sep	636	569	637	751		**648**
Oct	-	487	505	841		**611**
Nov	632	585	793	814		**706**
Dec	766	841	841	841		**822**
Annual	-	7,975	9,085	9,420		**8,922 MWh/year**
FUF [%]		80.56%	91.78%	95.17%		**90.13%**

Note: Dry season: from May to October, Wet season: from November to April

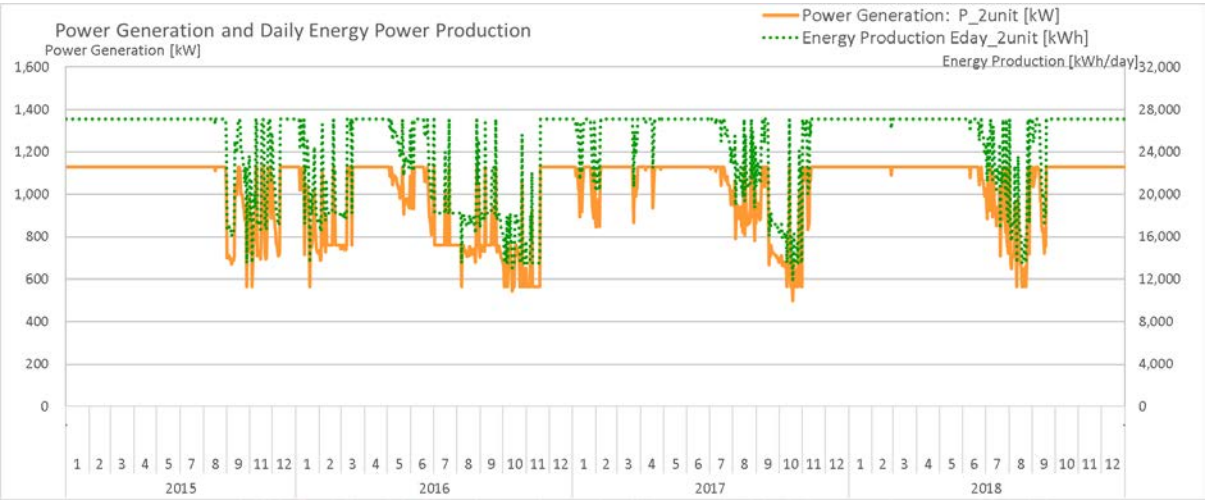


Figure 2.2-16 Calculation results of generated energy based on duration curve of each year (2015~2018)

2.2.2.3 Civil Engineering Plan

(1) Overall Plan

Civil engineering facilities of the hydropower plant including an intake weir, sand settling basin, headrace channel, head tank, penstock, spillway and powerhouse. The main components of civil engineering facilities are shown below.

Table 2.2-9 Main components of civil engineering facilities

Components	Specifications
Intake weir	H=8m, W=57.8m
Sand settling basin	L=27.25m, H=4.1m, W=7m
Headrace channel	Single line, L=1.2km, W=2m, H=2m, I=1/500
Head tank	L=39m, H=3.9m, W=8m
Penstock and spillway	ϕ1500mm-φ1100mm, L=59.8m / ϕ1500mm-φ1100mm, L=43.0m
Basement of powerhouse and tailrace	Double lines, L=1.2km, W= 1 m, H=1.8m, I=1/100
Building of powerhouse	Two-storied reinforced concrete building, total floor space: 350m^2

(2) Facility Plan

1) Layout Plan

The location of the intake weir was determined by taking into account the higher head and preventing the back water from adversely affecting the existing hydropower plant at the upstream. The location of the powerhouse was selected in such a way that the penstock is located between the powerhouse and the head tank, and the distance between powerhouse and head tank is as short as possible. The headrace channel is laid out on the left bank of the river, to keep a longitudinal slope of 1/500 between the intake facilities and the head tank. The length of the channel is approximately 1.2km. The general layout plan is shown as Figure 2.2-17.

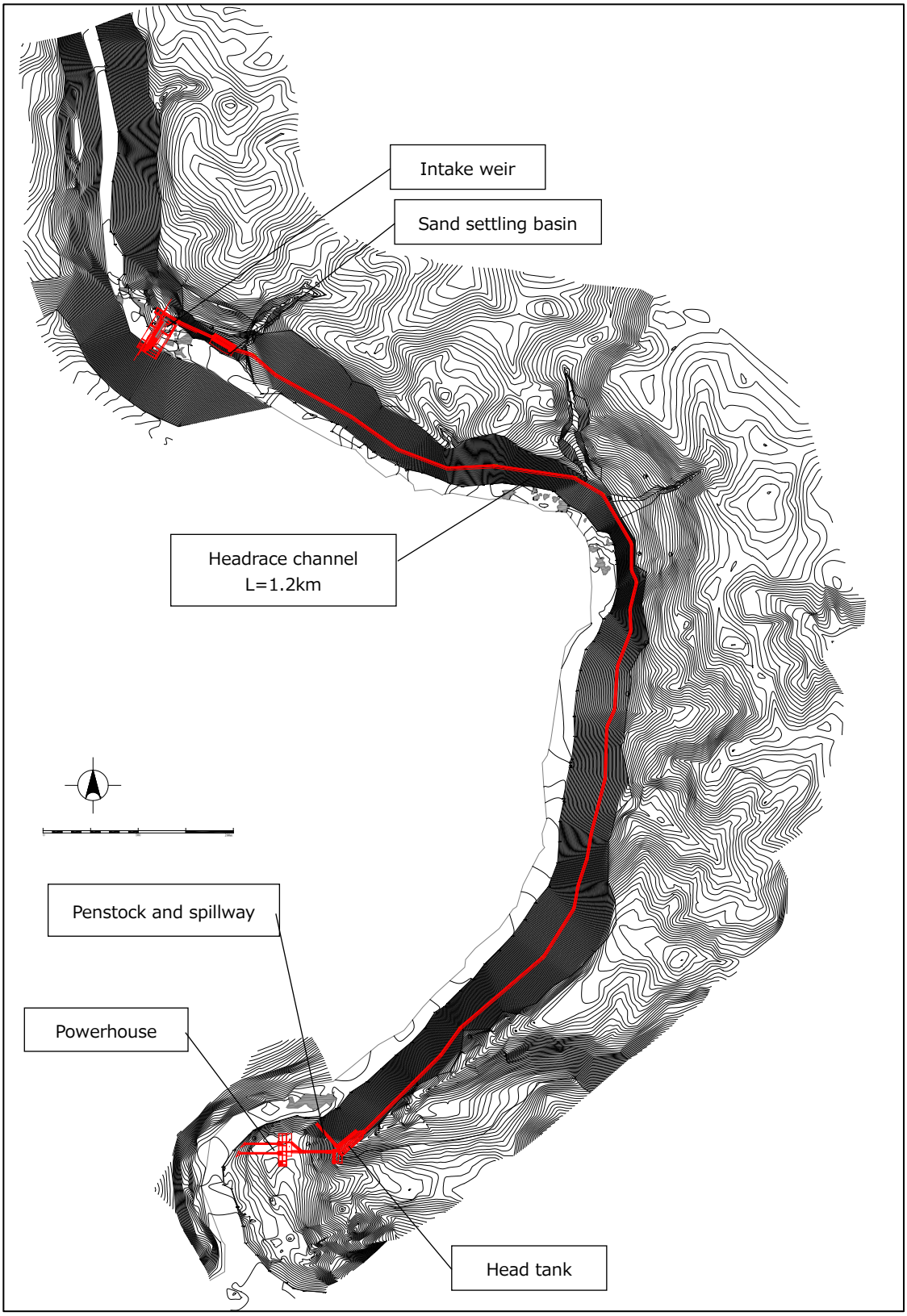


Figure 2.2-17 The general layout design

2) Sectional and Structural Plan

a) Intake Weir

The intake weir is a concrete gravity type. The surface of the weir is constructed with a rich mixture concrete and the weir body is constructed with a lean-mix concrete. Lean-mix concrete with less cement content contributes to the prevention of thermal cracking in mass concrete, as well as, the reduction of material costs. The intake weir has a sand flush gate (a sluice gate 2m × 2m). Design conditions of the intake weir are shown below.

Weir height	:	12.50m
Crest length	:	57.75m
Slope gradient	:	Vertical at upstream, 1:1.0 at downstream
Normal water level	:	EL.108.00m
Flood water level	:	EL.111.39m

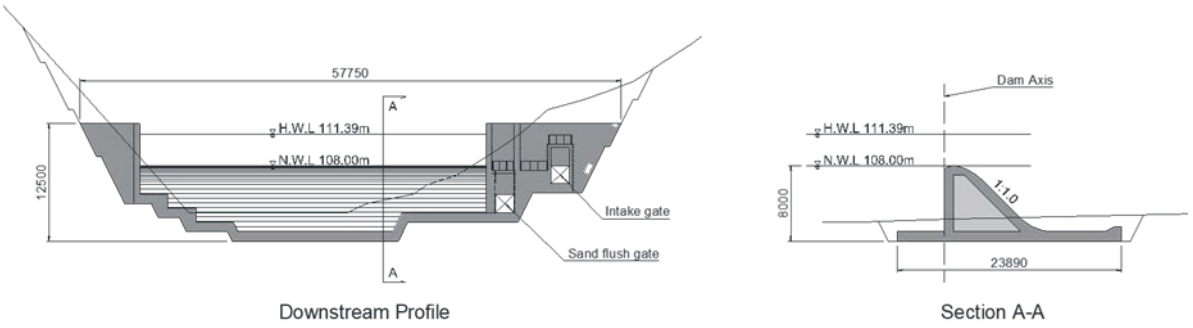


Figure 2.2-18 Profile and cross-section of intake weir

b) Intake

The intake gate (a sluice gate 2m in width 1.9m in height) is installed at the left side of the weir to control the power discharge. The intake has a screen to prevent floating logs, other vegetation from flowing into the intake.

c) Sand settling basin

The sand settling basin (7.0m in width, 27.25m in length and 4.10m in depth) is located around 60 m downstream from the intake. The capacity of the sand settling basin is designed to accumulate earth and sand generated by the water flow, which is required for the maximum power generation including the future extension. The sand settling basin has a reservoir to control the power discharge.

d) Headrace Channel

The headrace channel is an open channel with a rectangular cross-section. It is designed as a reinforced concrete structure, which is capable of resisting loads applied due to earth, water and seism. The gradient of the channel is between 1/465 and 1/500, to prevent the accumulation of soil. And, the channel is nearly twice as steep as that of the existing channel where soil accumulation has been observed. The design flow rate

is set to 6.30m^3/sec to satisfy the design flow rate of 4.20m^3/sec for the current design, and 2.10m^3/sec for future extensions. The design conditions of the headrace channel are shown below.

Length	:	1,207m
Gradient	:	1/465~1/500
Roughness coefficient	:	0.015
Discharge section	:	2.0m in width, 2.0m in height
Water depth	:	1.57m (Q=6.30m^3/sec)

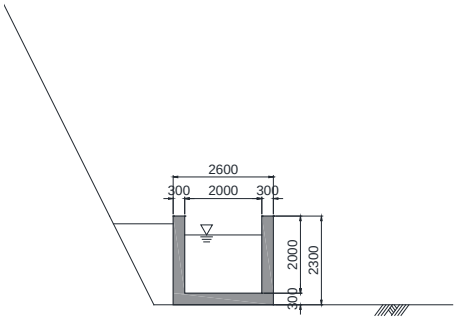


Figure 2.2-19 Cross-section of headrace channel

e) Head Tank

The head tank (8.0m in width, 39.0m in length and 3.90m in depth) is located between the headrace channel and penstock. The capacity of the head tank is designed in such a way that it will secure the water flow required for the maximum power generation including the future extensions of 6.30m^3/sec even in case that the water flow is rapidly reduced because the intake gate or headrace channel is blocked by floating logs or falling soils and rocks. The surplus water is overflowed to the spillway.

f) Penstock

The penstock is designed taking into account the current design power discharge of 4.20m^3/s. A penstock for future extension is not procured in this project. However, additional space, necessary for the extension, are provided in the head tank and powerhouse. The penstock branches off into two pipes from the head tank, and then connects to the hydraulic turbine in the powerhouse. Design conditions of the penstock are shown below.

Inside diameter before branching	:	1.50m (Q = 4.20m^3/sec, v = 2.38m/sec)
Inside diameter after branching	:	1.10m (Q = 2.10m^3/sec, v = 2.18m/sec)
Pipe thickness	:	6 mm (minimum required value)

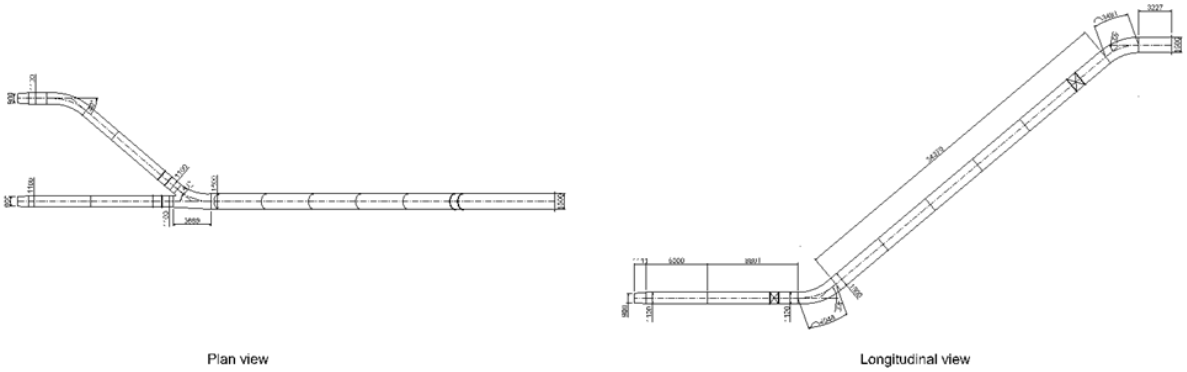


Figure 2.2-20 Plan and longitudinal view of penstock

g) Powerhouse Foundation

The powerhouse site is prepared by cutting ground and the floor level of the powerhouse building is the same level of cutting ground, i.e. EL 75.0m. Discharge pits is constructed right under turbines, which have overflow portions in order to keep mouths of draft tubes under water during operation and stopage of generation. A pit for No.3 unit for expansion plan is constructed.

h) Tailrace and Outlet

A Tailrace from each pits of unit No.1 and No.2 to the river is constructed, which is buried reinforced concrete culvert type. An inner section of the tailrace is determined so that the discharge can flow by free water and manual inspection is available. An inner section is 2m in width and 1.8m in height and a slope is 1/100. A length of No.1 tailrace is around 34 m and one of No.2 tailrace is around 39 m. An Outlet is constructed at the end of each tailrace, which can reduce the flow velocity.

2.2.2.4 Building Plan

(1) Floor Plan

The powerhouse has a square floor and a deck roof. The first floor has a hydraulic turbine generator room, rest room and shower room. The second floor has a control room. A space of the powerhouse building secures an area for No.1 and No.2 units in addition No.3 unit of expansion plan. However, an area for No.3 unit is utilized for maintenance space for No.1 and No.2 units. During expansion works, maintenance space is to be expanded.

(2) Section Plan

The powerhouse has two (2) stories above the ground, and a basement with pits and tailraces. The height of the 1st floor is decided so that the large scale of equipment can be carried in and out by the overhead travelling crane.

(3) Structural Plan

The powerhouse is a two-storied reinforced concrete building with a quake resistant wall-type frame structure. The building is designed to meet the following conditions: a base shear coefficient of 0.20 and a design wind speed of 50m/s.

(4) Electric and Machine Works

Electric and machine works include light fixture, water supply and drainage equipment, lightening protection system, air conditioning and ventilator facilities and the related works.

(5) Finishing Works

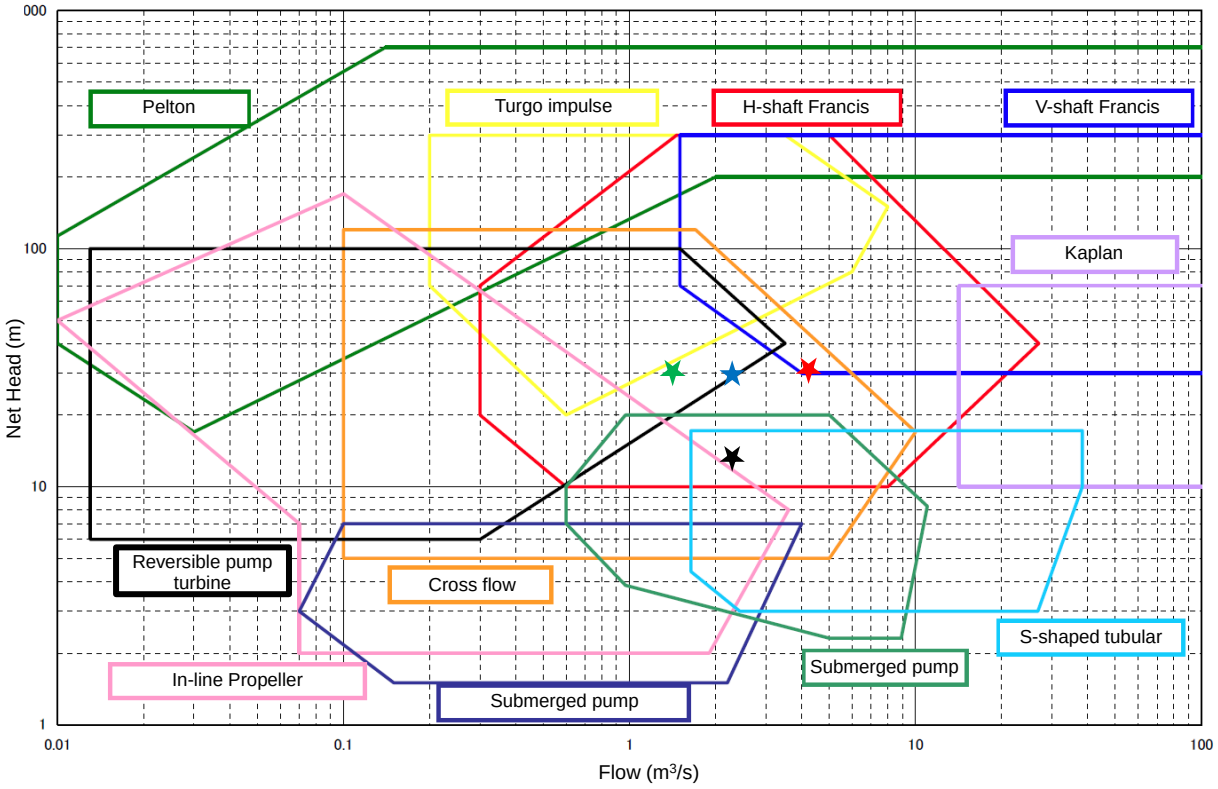
Finishing works include asphalt waterproofing and surfacing using steel trowel for roofs, exposed concrete finishing and acrylic resin coating for exterior walls, exposed concrete finishing for inner walls and surfacing using steel trowel and dustproofing paint for floors.

2.2.2.5 Equipment Plan

(1) Basic plan for Hydraulic Turbine and Generator

1) Type of Turbine

According to the Hydraulic Turbine Application Chart shown in Figure 2.2-21, there are two (2) options to install hydraulic turbine for the Project, and they are as follows; a) one (1) to three (3) Horizontal shaft (H-shaft) Francis turbines installed in parallel or b) a set of two (2) H-shaft Propeller turbines installed in two (2) rows.



★: H (Horizontal) -shaft Francis 1-Unit
★: H (Horizontal) -shaft Francis 2-Unit
★: H (Horizontal) -shaft Francis 3-Unit
★: H (Horizontal)-shaft Propeller 2-Unit x 2-Row

Source: Guidebook on Hydro Valley Planning (Ministry of Economy, Trade and Industry, Japan)

Figure 2.2-21 Hydraulic Turbine Application Chart

2) Numbers of Turbine

a) Policy for Numbers of Turbine

As a result of River flow duration curve analysis, it was confirmed that the water flow in the drought season will be reduced to 2.5 m^3/s approximately. Diesel generator must be operated as a backup for power generation and the fuel cost will be a huge burden of the electricity supplier (VUI), in case of troubles or maintenance with one turbine unit operation. Three (3) H-shaft Francis type turbines are installed and operated at the existing Sarakata Hydroelectric Power Plant.

In the light of these aspects, policies for turbine numbers are studied in each cases as follows.

- (Case-1 One H-shaft Francis unit) Since quantity of water flow for power generation is 2.5 m^3/s, turbine usage efficiency is less than 60% of the installed capacity. Thus power generation becomes less efficient and the generated output power is expected to be 400kW or lower.

- (Case-2 Two H-shaft Francis units) Quantity of water flow per turbine for power generation is 2.1m^3/s. One unit will be in full capacity operation and the others will be in non-operation state during the drought season. Output power is expected to be approximately 500kW.

- (Case-3 Three H-shaft Francis units) Quantity of water flow per turbine for power generation is 1.4 m^3/s. One unit will be in full capacity operation (output 300kW), second unit will be in operation at 70% of capacity (output 250kW) and third unit will be in non-operation state in the drought season. Output power is expected to be a total of approximately 550kW.

- (Case-4 Two H-shaft Propeller units in two rows) Water flow which is used for power generation is 2.1 m^3/s per row. One row (two units) will be in full capacity operation and the output power is expected to be a total of approximately 500kW (250kW x 2 units).

JICA Study Team compared the above-mentioned options from aspect of synchronized operation, output during the drought season, maintenance and accidents, price of equipment, cost of spare parts and so on and its result is shown in Table 2.2-10 and it is recommended to install two (2) to four (4) turbines in the Project.

Table 2.2-10 Comparison Study on Turbine Numbers

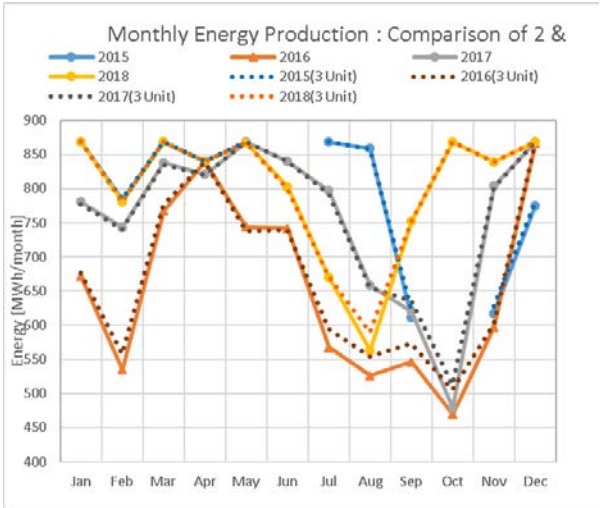
	H-shaft Francis 1 unit	H-shaft Francis 2 units	H-shaft Francis 3 units	H-shaft Propeller 4 units=2 units in 2 rows
Synchronized operation	N.A	++++	++++	+++
Power reduction during maintenance and accident	+	++	++++	+++
Price of Turbine (affordability)	++++	+++	+	+
Cost of transportation/ erection (affordability)	+	+++	+++	+++
Operation efficiency during drought	+	++	+++	++
Amount of spare parts (general versatility)	+	++	+++	+++
Comprehensive evaluation	8	16	18	15

b) Determination Unit Number of the Turbine

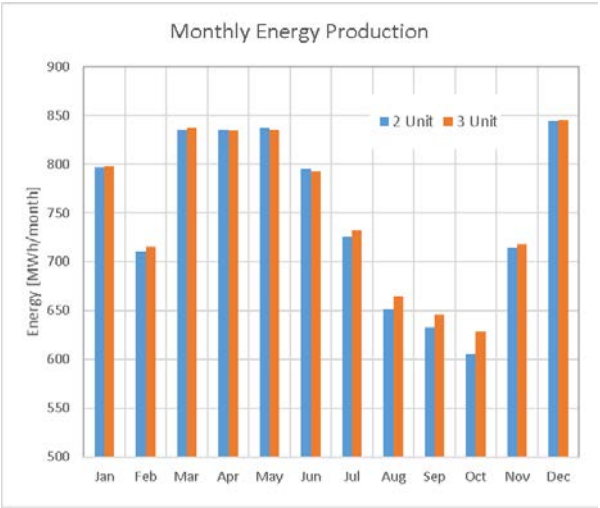
Calculation of energy generation was conducted based on the Combined Efficiency of Turbine and Generator which is presented in the "Hydropower Guide Manual for Development Aid Program and Studies of Hydro Electric Power Projects (New Energy Foundation, 1996)". The result of calculation, Figure 2.2-22 shows the daily energy production of each turbine with E1, E2, and E3 meaning energy production of each unit number 1, 2 and 3, respectively. Figure 2.2-23 shows the monthly energy production from 2015 to 2018 and the average monthly energy production.

These result show that although the annual average energy production with three (3) units is a little bit larger than the one of two (2) units, the difference is only minimal. In addition the cost for three (3) units is greater than two (2) units. Therefore, it is concluded that the two (2) unit case will be appropriate in consideration of cost-effectiveness.

Figure 2.2-22 Comparison of Energy Production with 2 units and 3 units



(Monthly energy production with 2 units and 3 units)



(monthly energy production : average of 2015－2018)

Figure 2.2-23 Comparison of Unit number (2 Units and 3 Units)

(2) Basic design of Hydraulic Turbine and Generator

According to the abovementioned studies, Two (2) H-shaft Francis turbines are thought to be best for the Project. Since H-shaft Francis turbine is adopted in the new power plant, there is an advantage that O&M staff are used to operating the turbine, generator and the electrical and control equipment that are applied in the existing power plant.

2.2.2.6 Power System Facility (Transmission, Substation, and grid facilities)

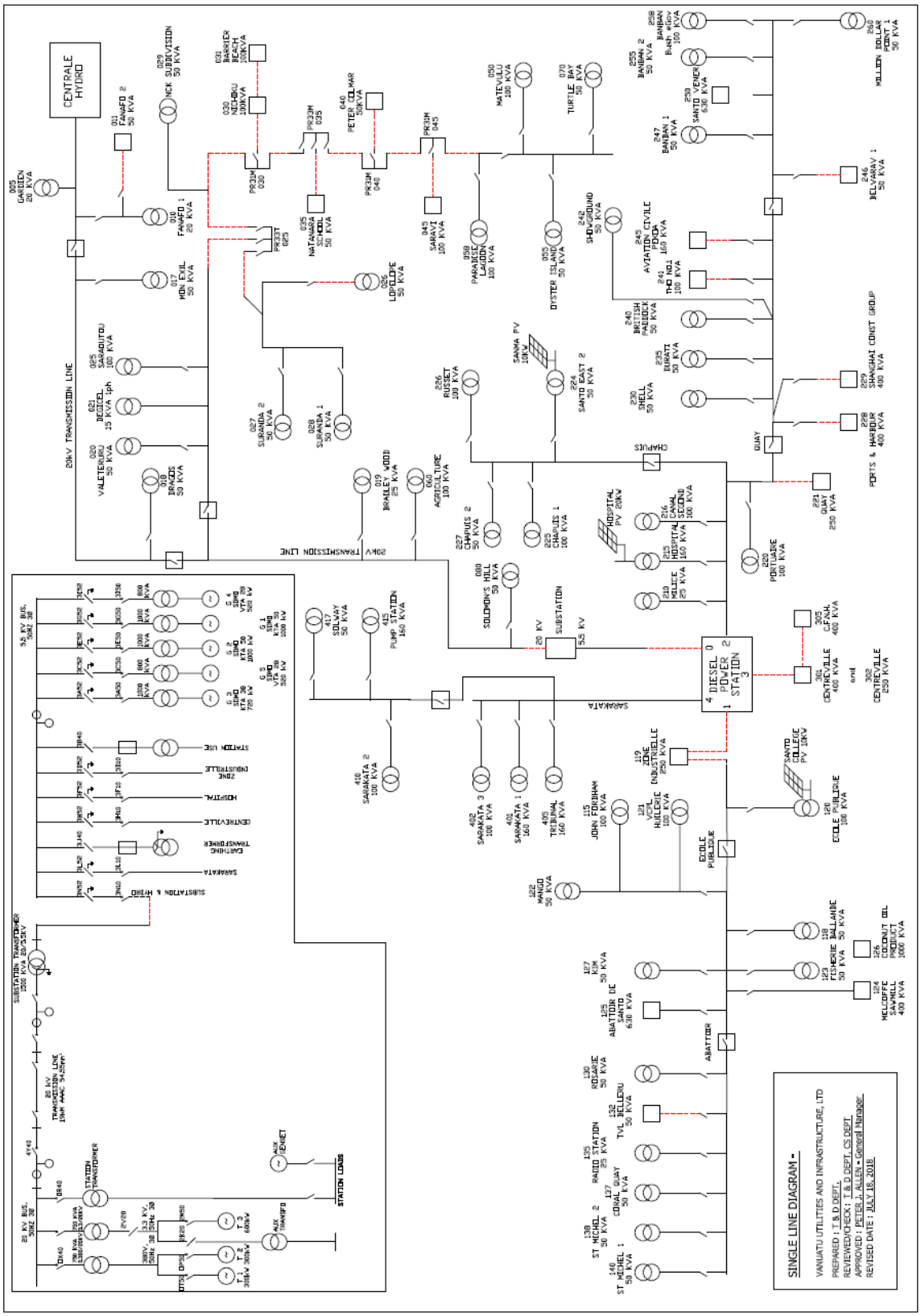
The new hydropower plant will be interconnected to the existing 20kV transmission line in this project. The amount of electric power to be transmitted by the existing line will increase with the grid interconnection. The problems caused by this increase are investigated.

(1) The power system in Luganville area

Luganville 20kV power system consists of one (1) circuit of a transmission line from Sarakata River Hydropower Station to Luganville substation with 1,500kVA transformer which stepdown to 5.5kV in the city area. The 5.5kV distribution system consists of one (1) power cable to the diesel power station and four (4) circuits of distribution lines that supply to the city area. Figure 2.2-24 shows the power system diagram in Luganville area.

The problem is that the 20kV transmission line does not satisfy with N-1 standards. Sarakata River Hydropower Station cannot operate continuously in the event of an accident with the present 20kV transmission line. It is desirable to install an additional line so that the Sarakata River Hydropower station operation can be continued in case of accident on one line. This measure is expected to significantly improve supply reliability.

System requirements such as the short circuit capacity, thermal capacity and voltage range was confirmed to be satisfied in case that the new hydropower station is interconnected. So, installation of an additional 20kV line is not included in this project.



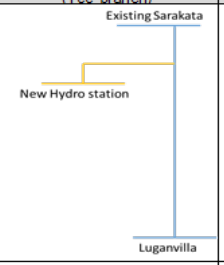
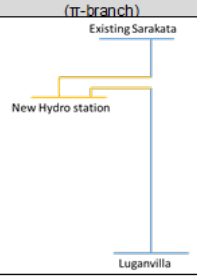
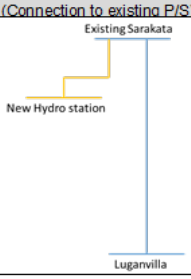
Source: VUI

Figure 2.2-24 The power system diagram of Luganville area

(2) Comparative study of alternatives for connecting new hydropower station

"Data collection survey on power sector in Espiritu Santo in Republic of Vanuatu", the previous study proposed a plan to connect to the existing 20kV transmission line by a T branch along the new access road when a new hydropower station is built on the downstream of the Sarakata River. Three alternatives including the above proposal are comprehensively evaluated from the viewpoints of reliability, feasibility, environmental impact, and cost in this project. Proposed plans are T-branch connection to an existing transmission line (Plan 1), π-branch connection to an existing transmission line (Plan 2), connecting directly to the existing Sarakata hydropower station (Plan 3).
The connection alternatives were evaluated and the results are shown in Table 2.2-11

Table 2.2-11 Comparative study of alternatives to connect the new hydropower station

		Existing	Plan 1 (Tee-branch)	Plan 2 (π-branch)	Plan 3 (Connection to existing P/S)
Power System Diagram					
Reliability	Power System		+ All G stopped by Line accident	+++	++++
	During Construction		++++	++++	+++
Feasibility	Transmission Line(T/L) Route		++++	++++	++
	Powerstation(P/S) Feeder Facility		++++	++++	+ little space at Existing P/S
Environmental Social Impact			++++	+++	+ need many logging
Cost	Construction of T/L (USD)		++ need communication system	++++	+++
Total Estimation			++	++++ (recommend)	++

Source: JICA Survey team

1) Plan 1

System reliability is lower than other alternatives because all hydropower stations cannot operate continuously when a 20kV transmission line accident occurs. In addition, it is necessary to install a three-terminal line protection relay to protect the line. In this regard, costs are additionally increased compared to other alternatives because all the overhead ground lines of the existing 20kV transmission lines have to be replaced with OPGW (Optical fiber composite overhead ground wire) and a communication equipment has to be installed.

2) Plan 2

Although slightly inferior to Plan 3 due to the capacity of the generator that can be continuously operated in the event of an accident, the system reliability is higher than Plan 1 because the new hydropower station can be operated continuously even if a transmission line accident occurs between the existing hydropower station and the new one. In terms of cost, OPGW and communication equipment for transmission line protection relays which are required for Plan 1 are not required, and the additional buildings, switches and control

panels at the existing power plants which are required for Plan 3 are not required. The cost increase caused by construction of two lines up to the existing transmission line is smaller than costs of other plans. Regarding feasibility, it is considered appropriate to extend the existing railway along the new access road.

3) Plan 3

It is necessary to expand the building of the existing power station since there is no space to install switchgears and control panels in the existing power station. In this regard, the cost incurred for the building and switching equipment is expected to be higher when compared to Plan 2. This plan is determined to be less feasible than the other two because the new transmission line is separated from the new access route and it is necessary to bring the transmission line from the steep and high river bank to the existing power station. New transmission line is deviated from the newly constructed access road, and an additional logging is necessary. Because of this reason, the environmental impact is determined to be inferior when compared to other plans.

4) Plan to be adopted

From the above comparison, Plan 2 (π connection to existing 20kV transmission line), which can overcome the shortcomings of Plan 1 and Plan 3, will be adopted.

(3) Power system analysis

1) Criteria for power system analysis

The existing Sarakata River hydropower station has the capacity of one (1) 600kW and two (2) 300kW. In addition to this, it is necessary to consider whether the system constraints on thermal capacity, voltage range, and short-circuit capacity of the existing system facilities are sufficient after the grid interconnection of the new power station. The condition of the voltage range is specified to be within ± 7% at 5.5 kV lines from the URA “Electricity Reliability Standard”. Although the voltage range is not clearly specified for the 20kV transmission line, it is necessary to keep the voltage within the range of 18-22 kV which is within the voltage control range of the existing on-load tap change transformer, in order to keep the above voltage range at the Luganville substation. The power output of the new power station is assumed to be 1,000kW. The 20kV transmission line is set along the access road based on the results of this survey, and the connection point of each transmission line as shown in Figure 2.2-25 is set as the interconnection point for power system analysis. According to Figure 2.2-25, the length of the 20kV transmission line is 20.5 km between the existing hydropower station and the existing substation, and it is approximately 2km between the existing hydropower station and the interconnection point, and approximately 4km between the interconnection point and the new power station.

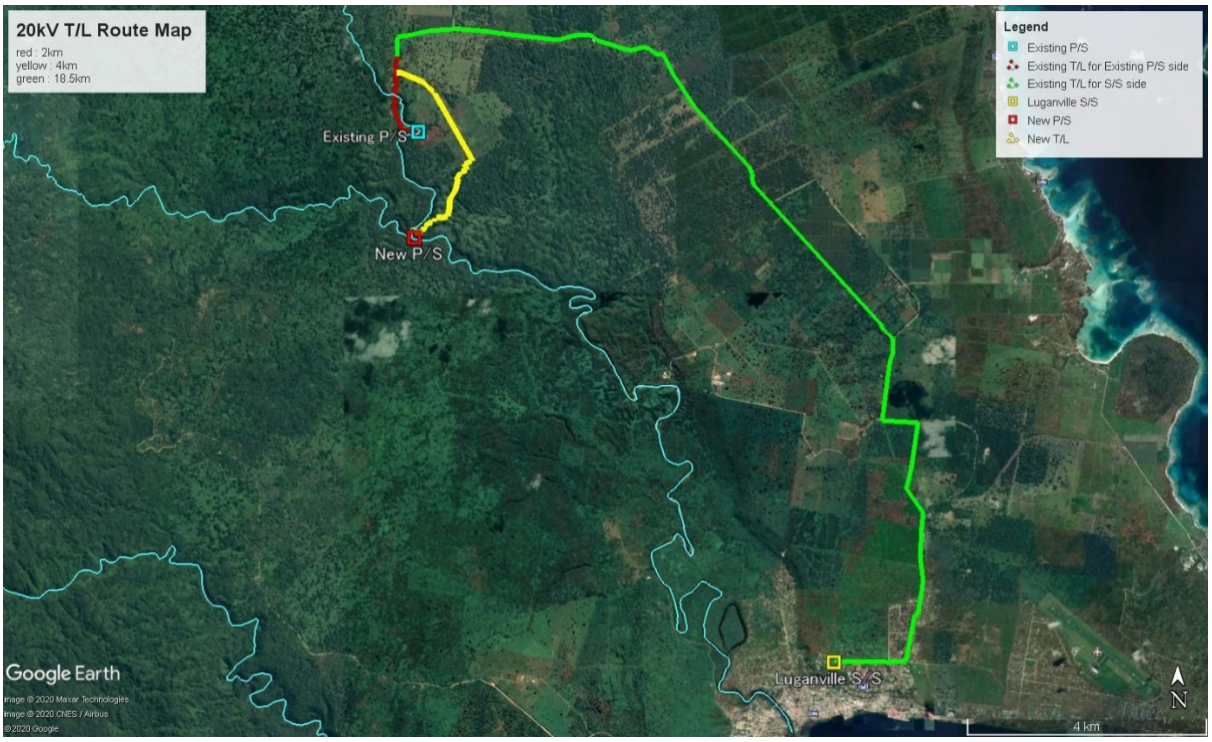


Figure 2.2-25 20kV Luganville Power System Overview

2) Study result of existing 20kV transmission line

The amount of current passed through the 20kV transmission line is about 35A, which satisfies the capacity of the wire used (ACSR-OC 58mm^2), 205A (ambient temperature 40 ° C). The Luganville substation transformer capacity is 1,500 kVA and the annual peak power factor is 0.86, which indicated the capacity for generated power, i.e. 1,200 kW, has been secured. As for the voltage drop, the calculation is performed under the strictest conditions that power would not be consumed by the load connected to the 20 kV transmission line. As a result, the voltage at the existing substation is calculated to be 19.05 kV. This value is within the voltage control range (18-22kV) of the Luganville substation transformer.

3) Study result of 20kV transmission line after interconnection of the new power station

The maximum short-circuit current is 6.48 kA, which is within 12.5 kA, the short-circuit capacity of the existing power transmission line facilities. And the amount of current flowing through the transmission line is about 64A. This value satisfies 205A at an ambient temperature of 40 ° C, which is the capacity of the existing cable (ACSR-OC 58mm^2). On the other hand, the transformer capacity of the Luganville substation has to be 2,200 kW, which is the total output of the existing and the newly installed hydropower generators. Therefore, replacement with a 3,000 kVA transformer or installation of an additional 1,500 kVA transformer at Luganville Substation is required. As for the voltage drop, the calculation is performed under the strictest conditions that power would not be consumed by the load connected to the 20 kV transmission line. As a result, the voltage at the existing substation is calculated to be 18.08kV. This value is within the voltage control range (18-22kV) of the Luganville substation transformer.

From the above, it can be confirmed that the system constraints are satisfied.

4) Study result of 5.5kV distribution line between Luganville substation and Diesel power plants after interconnection of the new power station

The input of the existing diesel generators connected to the 5.5kV distribution line can be reduced and the short-circuit capacity can be reduced with interconnection of the new hydropower station. Thus, it is not necessary to replace the existing equipment of the entire 5.5kV lines. Furthermore, the voltage can be adjusted to the appropriate voltage according to the load by the on-load tap change transformer. Therefore, the thermal capacity of the 5.5kV distribution line between Luganville Substation and Diesel Power Station poses a problem to the interconnection of the new hydropower station. This distribution line is composed of an overhead line and an underground line. The section of the overhead line is 340m, and the line type is ACSR-OC 58mm^2. The section of the underground line is 260m, and the line type is XLPE 240mm^2 (aluminum, armored, 4 cores). The thermal capacity is 205A for both the overhead line and the underground line. Considering that the transmission loss can be calculated as 218 kW and that the load interconnected to the 20 kV transmission line is always 229 kW, the thermal capacity is sufficient because the current is calculated to flow at 184 A in the 5.5 kV distribution line.

From the above, it can be confirmed that the system constraints are satisfied.

In this regards, when the 20kV transmission line is replaced or changed to a bigger size or when one more 20kV transmission line is installed in the future, the amount of current passing through this 5.5kV distribution line will increase and the thermal capacity may be insufficient due to the transmission loss reduction. Replacing it with a bigger size conductor or installing one more 20kV transmission line will be required in that case.

5) Conclusion

As a result of the system review, it can be concluded as follows.

Regarding the system constraints, other than the transformer capacity at Luganville Substation, the current existing 20kV transmission line and substation equipment and distribution lines can transmit the power after interconnection of the new hydropower station. On the other hand, the transformer capacity of Luganville Substation will be short of 1,250kVA. To deal with this, there are two options: adding another 1,500 kVA transformer and operating two in parallel, or replacing it with a 3,000 kVA transformer. For parallel operation of two (2) transformers, a new 20kV and 5.5kV busbar and 5.5kV switching equipment will be required, which will significantly increase cost. Based on this, it is recommended to replace the existing transformer with a 3,000kVA transformer from the viewpoint of cost, instead of adding a second 1,500kVA transformer. The 1,500kVA transformer should remain, and if the 3,000kVA transformer fails, this transformer will be connected as an emergency, while limiting the output of the generator. Regarding the voltage drop, since the voltage at the Luganville substation, which is the receiving end, is calculated close to the lower limit (18kV) voltage of the tap changer, it is recommended to change the step-up transformer's tap and adjust voltage of the existing hydropower station from 20 kV to 21 kV.

The main purpose of this new hydropower project study is to evaluate how to connect the new hydropower station. However, in order to improve the system reliability and reduce the transmission loss in the future so that the clean energy generated by the hydropower stations can be used more efficiently, implementation of these projects are desirable.

(4) Design of Power Grid Facilities

No protection equipment is installed for the existing power grid facilities, especially, the existing hydropower plant and substation for transmission lines. Therefore, once the accidents occur, no protection is conducted for equipment. In case that the new power plant interconnect to the existing power grid, formulation of protection system became more complicated because the 3-direction system grid (transmission lines to existing power plant, new hydropower plant and substation) is complicated. A large scale renovation is required for the existing transmission equipment without grid protection equipment. It takes several months to renovate the equipment, so it is assumed that blackout in Luganville area occurs for several months. Considering this situation, π-branch is set at the transmission line from the existing power plant and one to the substation and the electric power of the existing power plant is transmitted to a new power plant once by 2 lines of a new 20 kV transmission line.

Because communication by radio transmission is unstable in the project area, fiber-optic cable is laid on concrete poles of existing and new 20 kV transmission line and communication signals is to be transmitted in order to ensure the remote operation from the existing power plant to a new power plant to be planned.

Single diagram of 20 kV transmission line is shown in Figure 2.2-43, which includes π-branch connection at the existing transmission line from the existing power plant and one to the substation.

2.2.2.7 Access Road

(1) Overall Plan

There are no passable roads from the existing road to the project site. Therefore, a new access road to the intake weir and powerhouse is constructed in this project. The route of the access road starts at the local road in the north, and it passes through the plantation farm and forest land, and ends at the intake weir and powerhouse. The total road length is about 6.2km including the distance of about 4.7km between the entrance of plantation farm and powerhouse, and about 1.5km between the junction and intake weir.

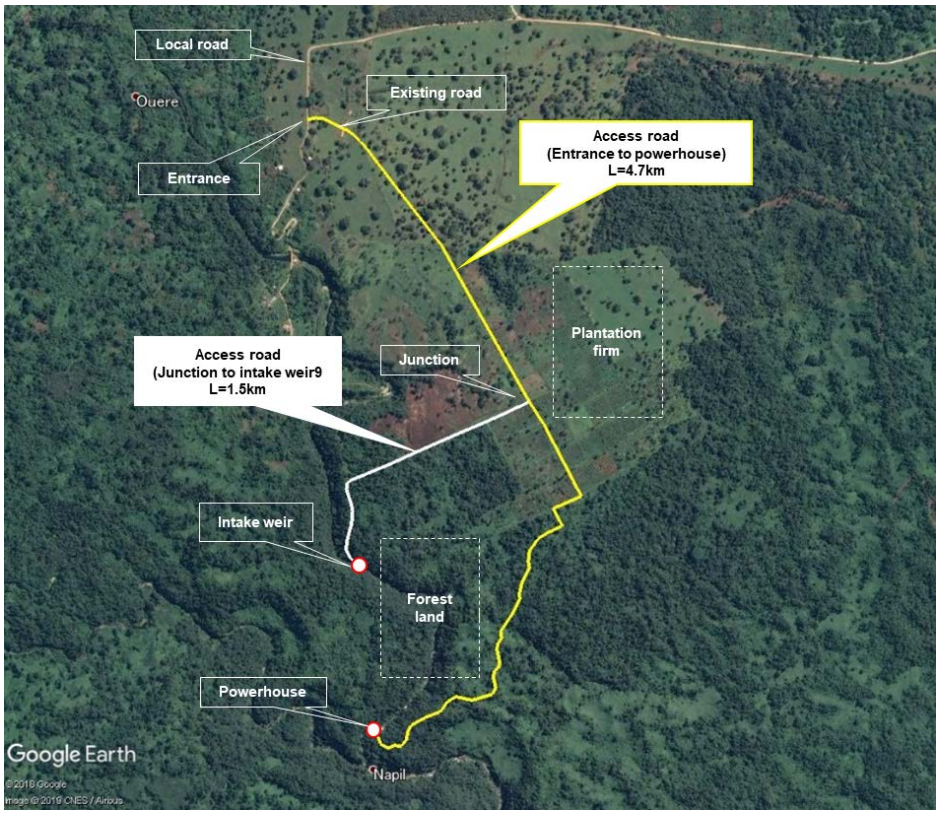


Figure 2.2-26 Plain view of access road

(2) Road Alignment

The plantation area is comparatively flat. However, the project site is located along a deep V-shaped valley. Therefore, the road alignment is strongly affected by the landscape.

Photo 2.2-1 V-shaped valley around the project site

The design of access road will comply with the standards for forest road established by Ministry of Agriculture, Forestry and Fisheries of Japan. Structural specifications of the access road are shown as follow;

Class	Second class
Design speed	20km/h
Width of traffic lane	3.0m
Width of shoulder	0.5m on both sides
Minimum radius of curve	10m (exception value)
Maximum longitudinal slope	10%

As mentioned above, the total width of the access road is planned to be 4.0m with one lane, and the vehicles cannot pass each other. Lay-by places should be designed at flat areas accordingly.

(3) Cross-section Plan

The roadway width includes a traffic lane of 3.0m, two shoulders of 0.5m width each, and two drainages of 0.5m width each. The road has macadam pavements with local coral limestone.

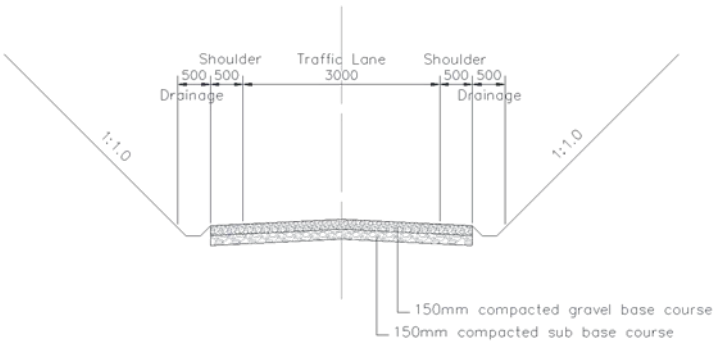


Figure 2.2-27 Typical cross-section of access road

The standard gradients of cut and banking slopes conform to the standards of the Japan Road Association.

Table 2.2-12 Standard gradients of slope

Soil works	Soil classification	Slope	Berms
Cut	Sand	1:1.0	1m in width for every 10m in height
	Soft rock	1:0.5	
Banking	Sand	1:1.8	1m in width for every 5m in height

2.2.3 Outline Design Drawing

2.2.3.1 Civil Engineering Facility

The drawings of civil engineering facility are shown in Figure 2.2-28 to Figure 2.2-34.

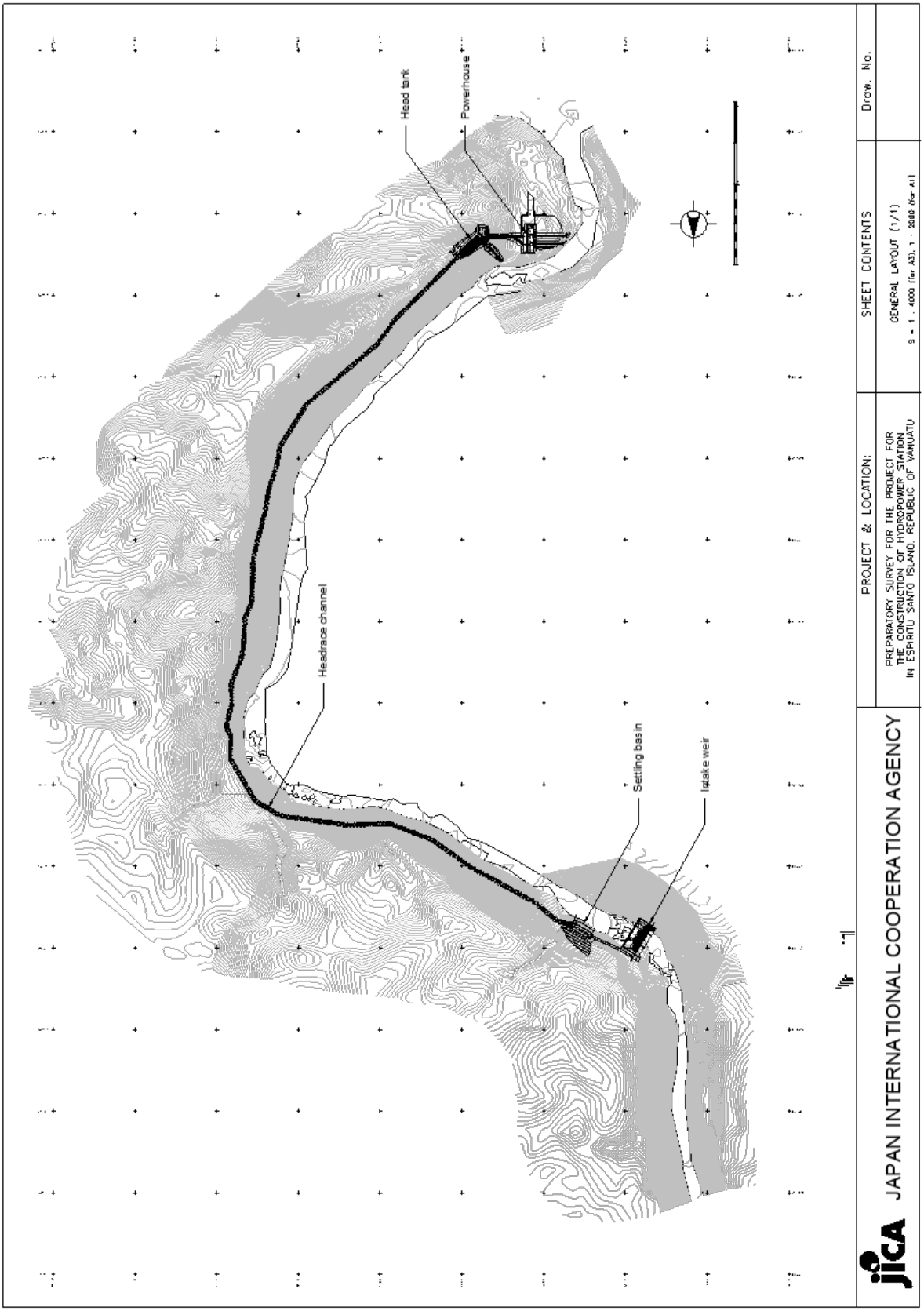


Figure 2.2-28 General Layout

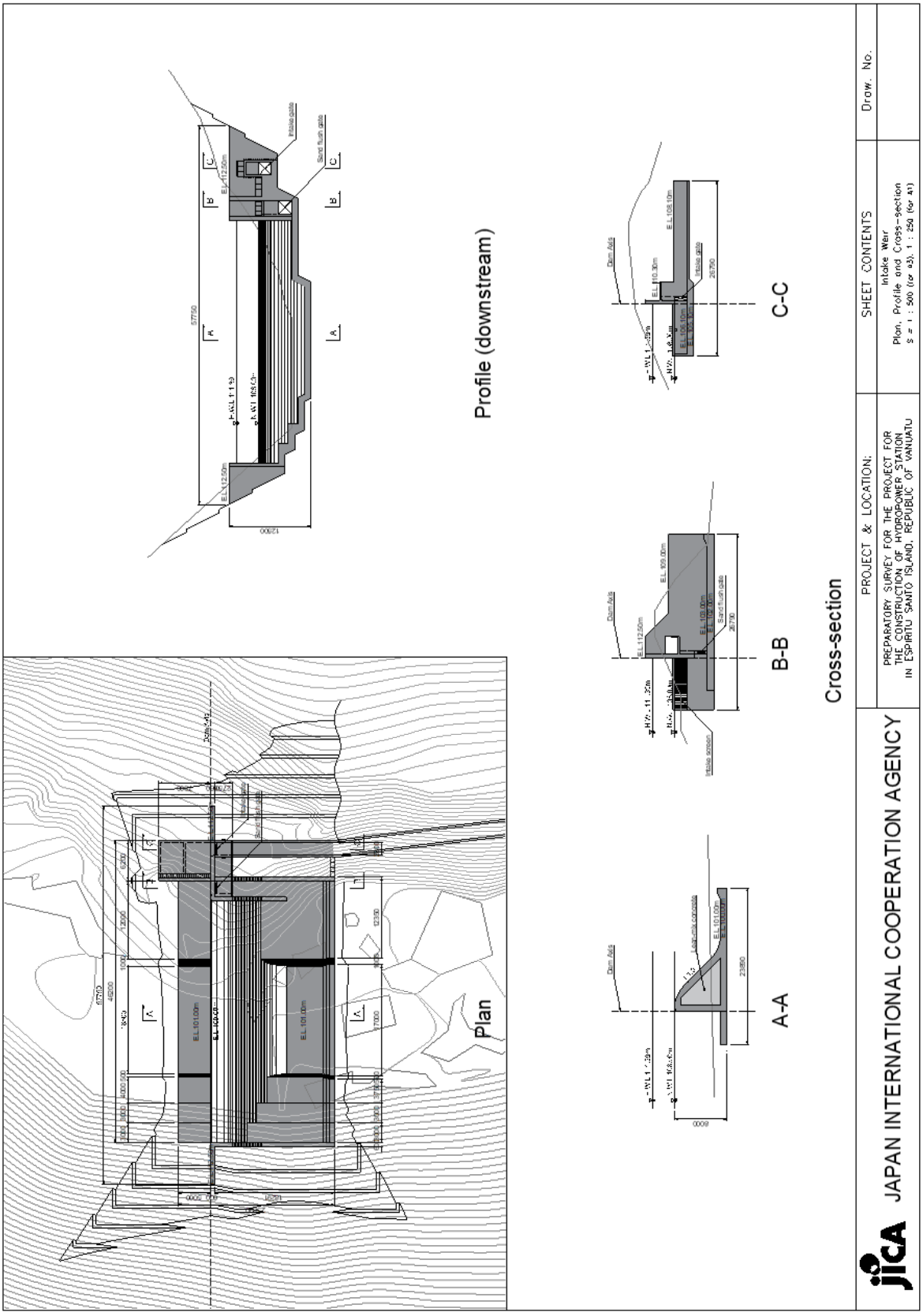


Figure 2.2-29 Intake Weir

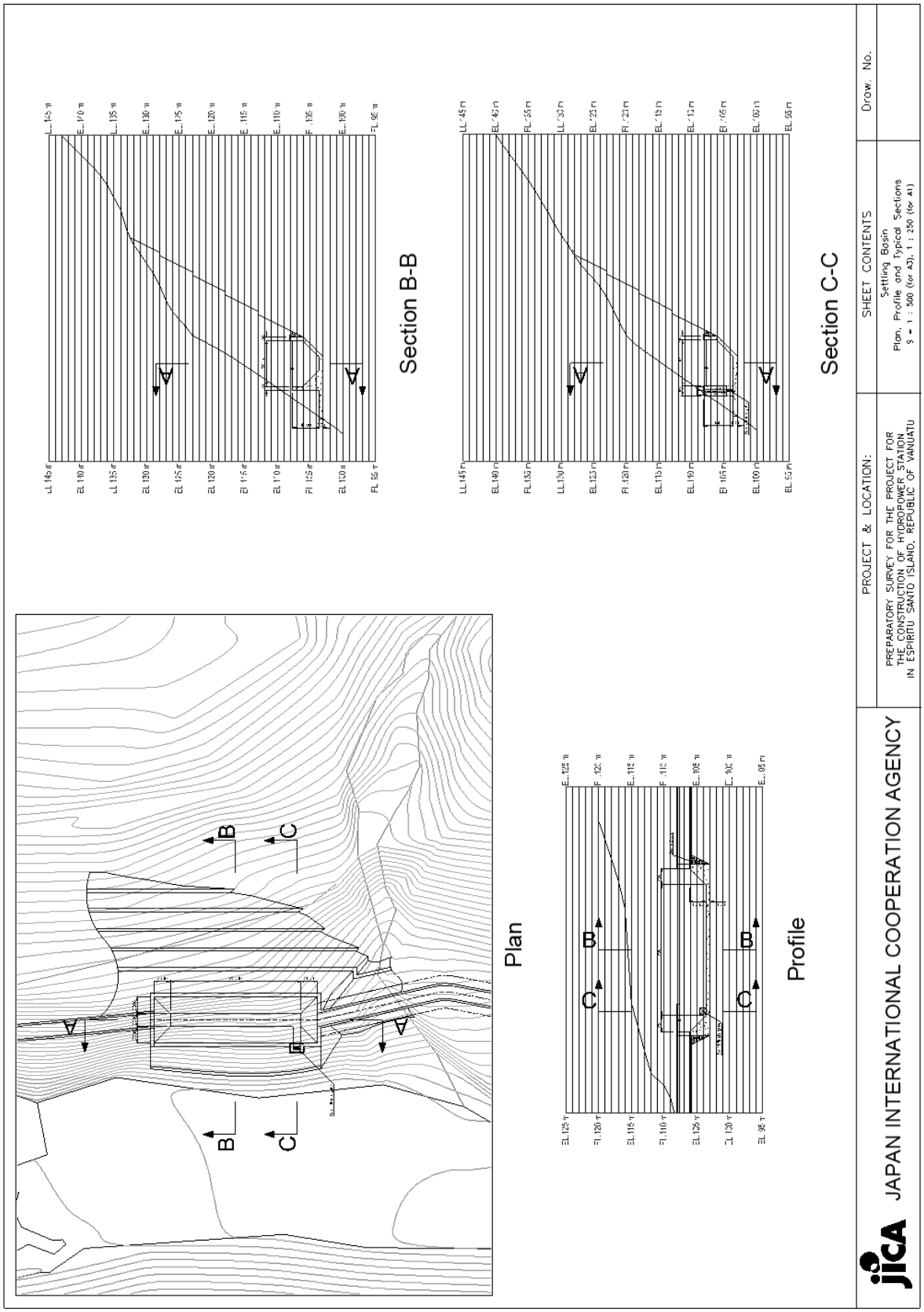


Figure 2.2-30 Settling Basin

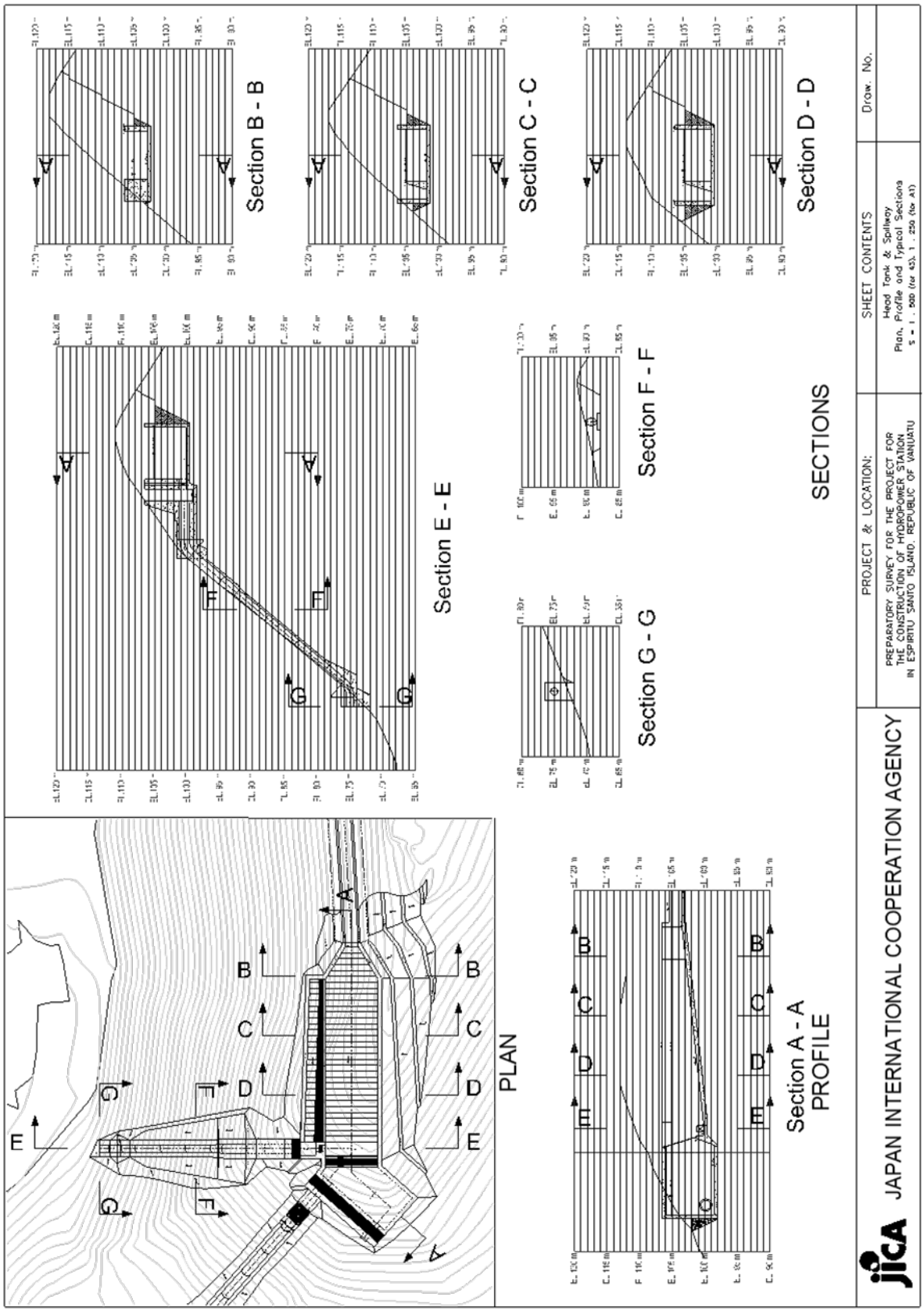


Figure 2.2-31 Head Tank and Spillway

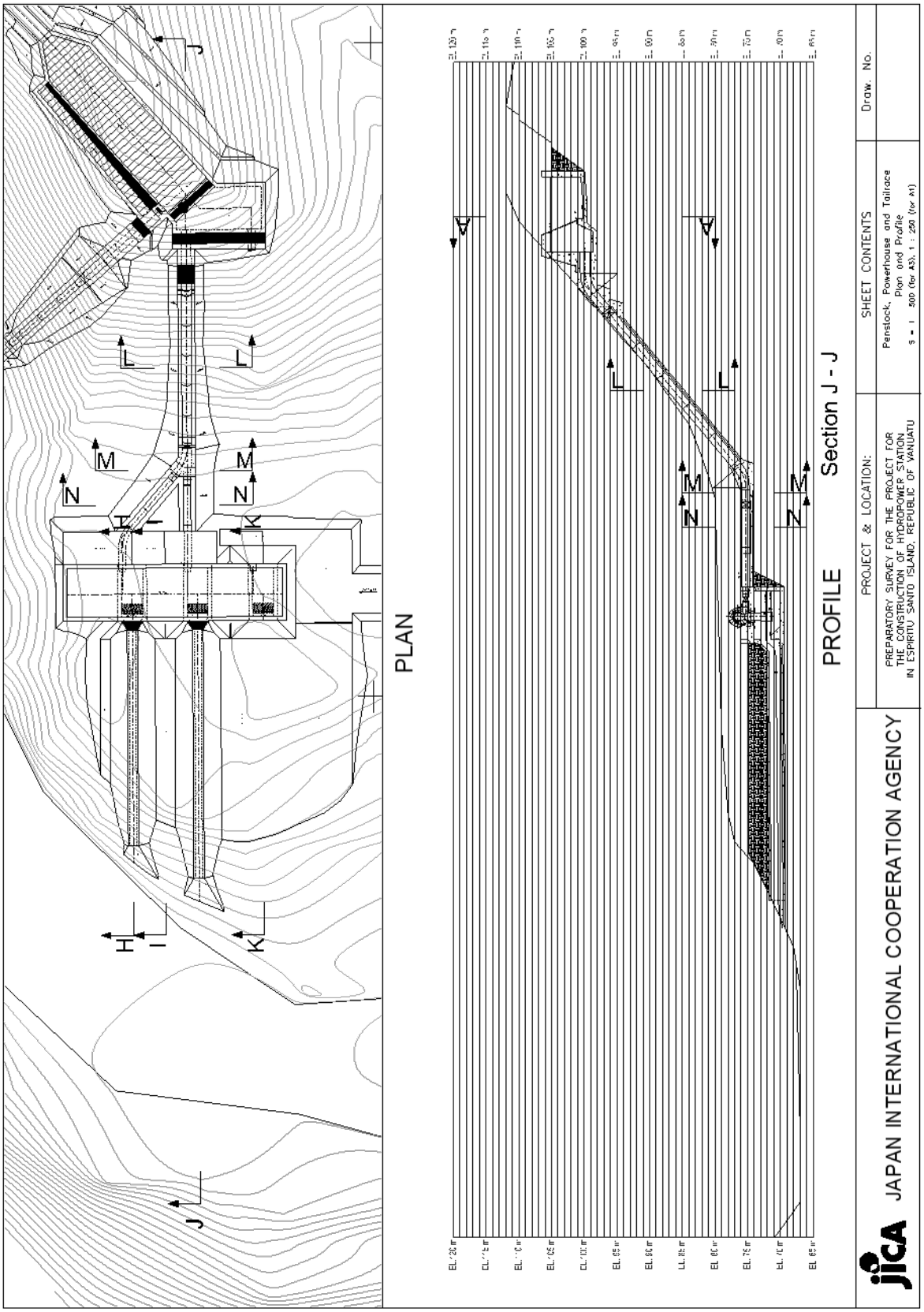


Figure 2.2-32 Penstock, Powerhouse and Tailrace (1/2)

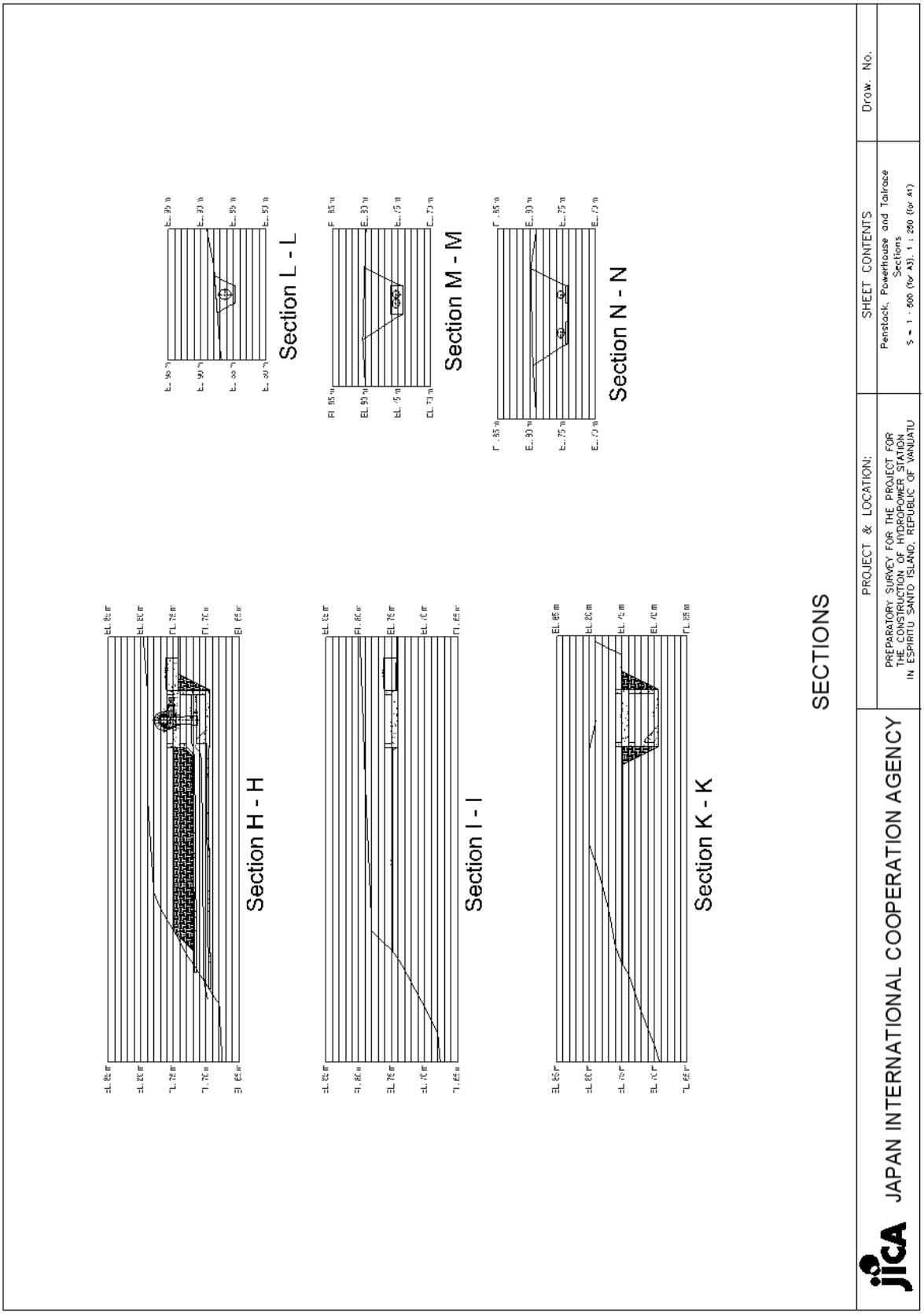


Figure 2.2-33 Penstock, Powerhouse and Tailrace (2/2)

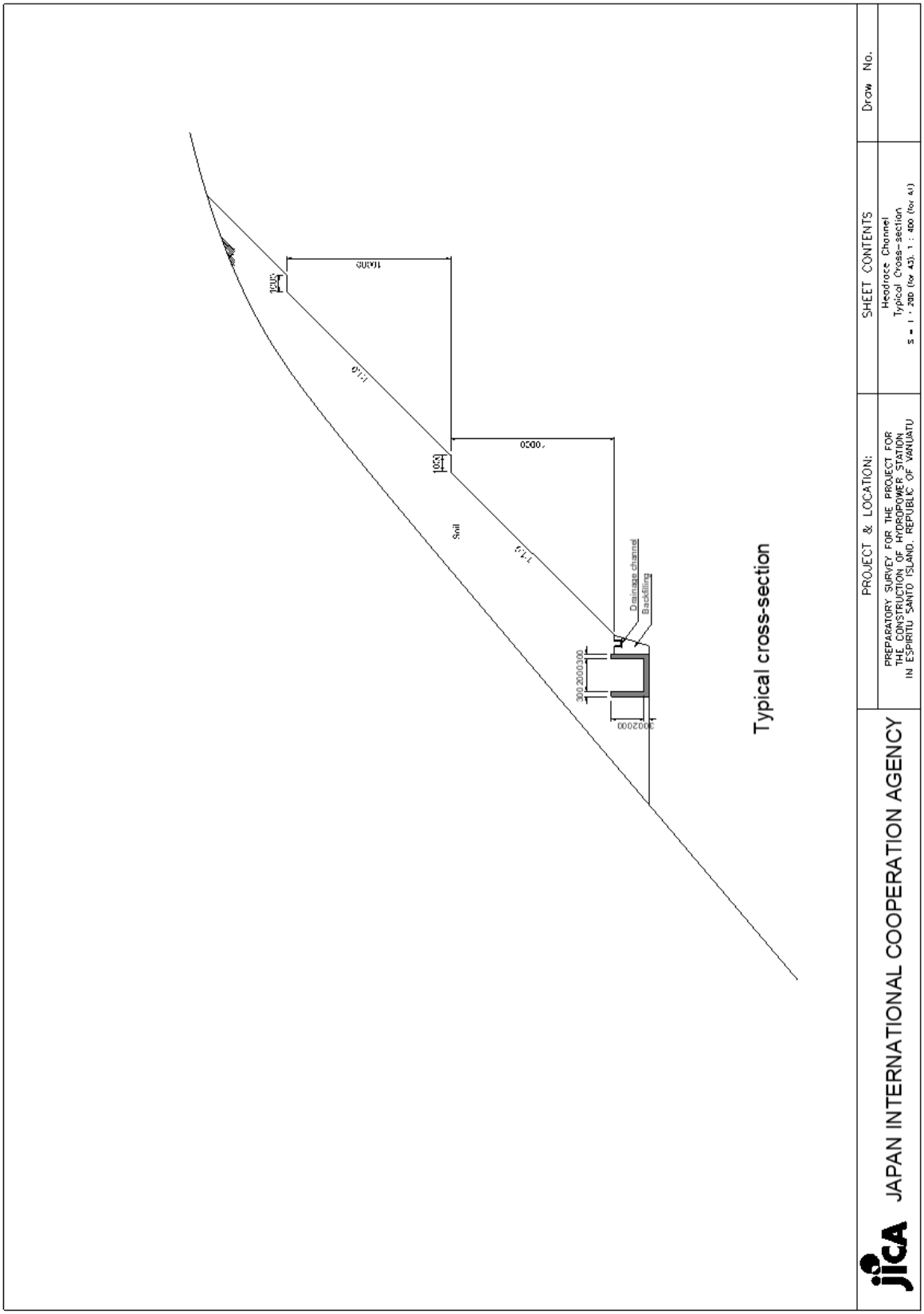


Figure 2.2-34 Headrace Channel

2.2.3.2 Building Facility

The drawings of building facility are shown in Figure 2.2-35 to Figure 2.2-37.

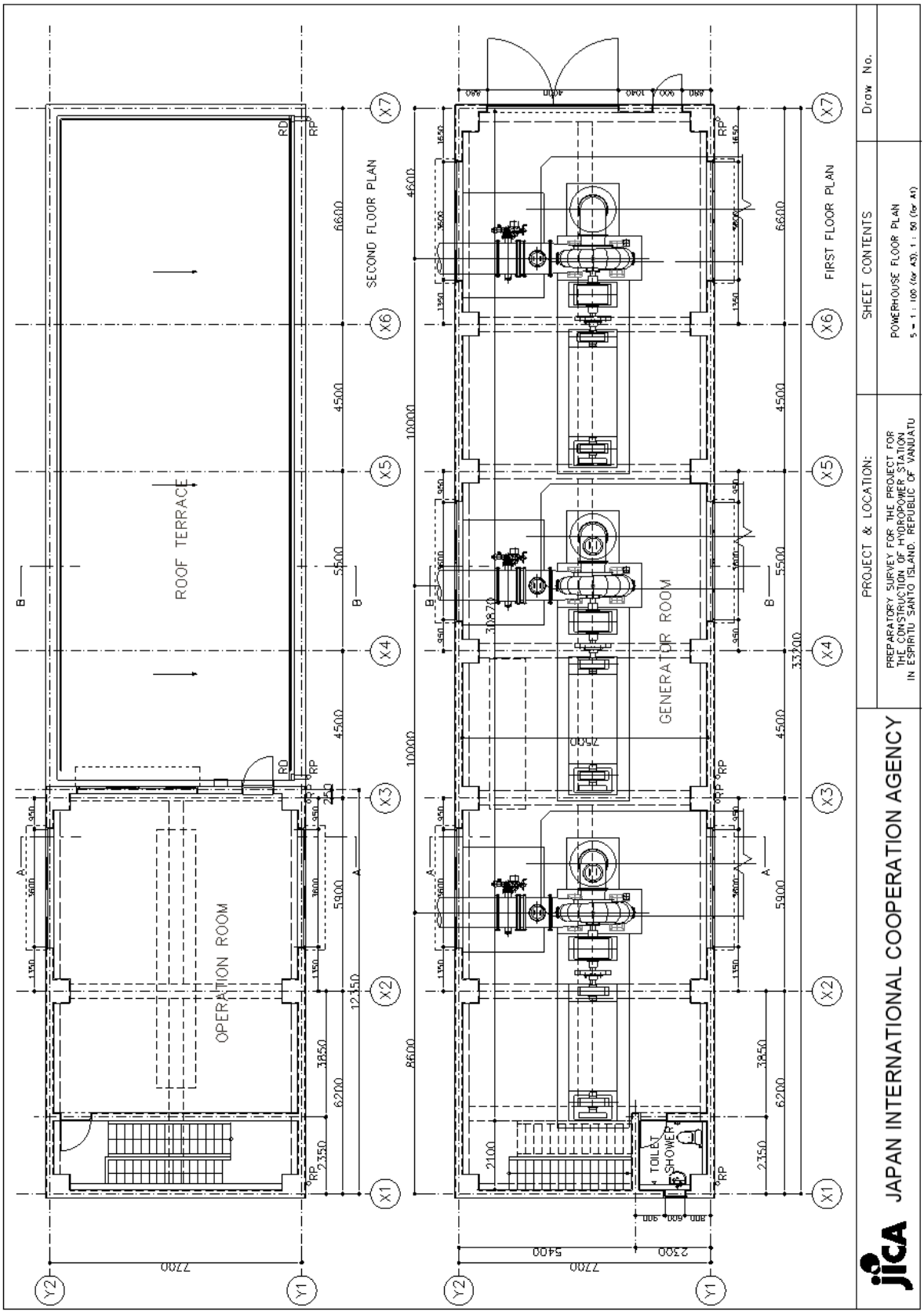


Figure 2.2-35 Floor Plan of Powerhouse

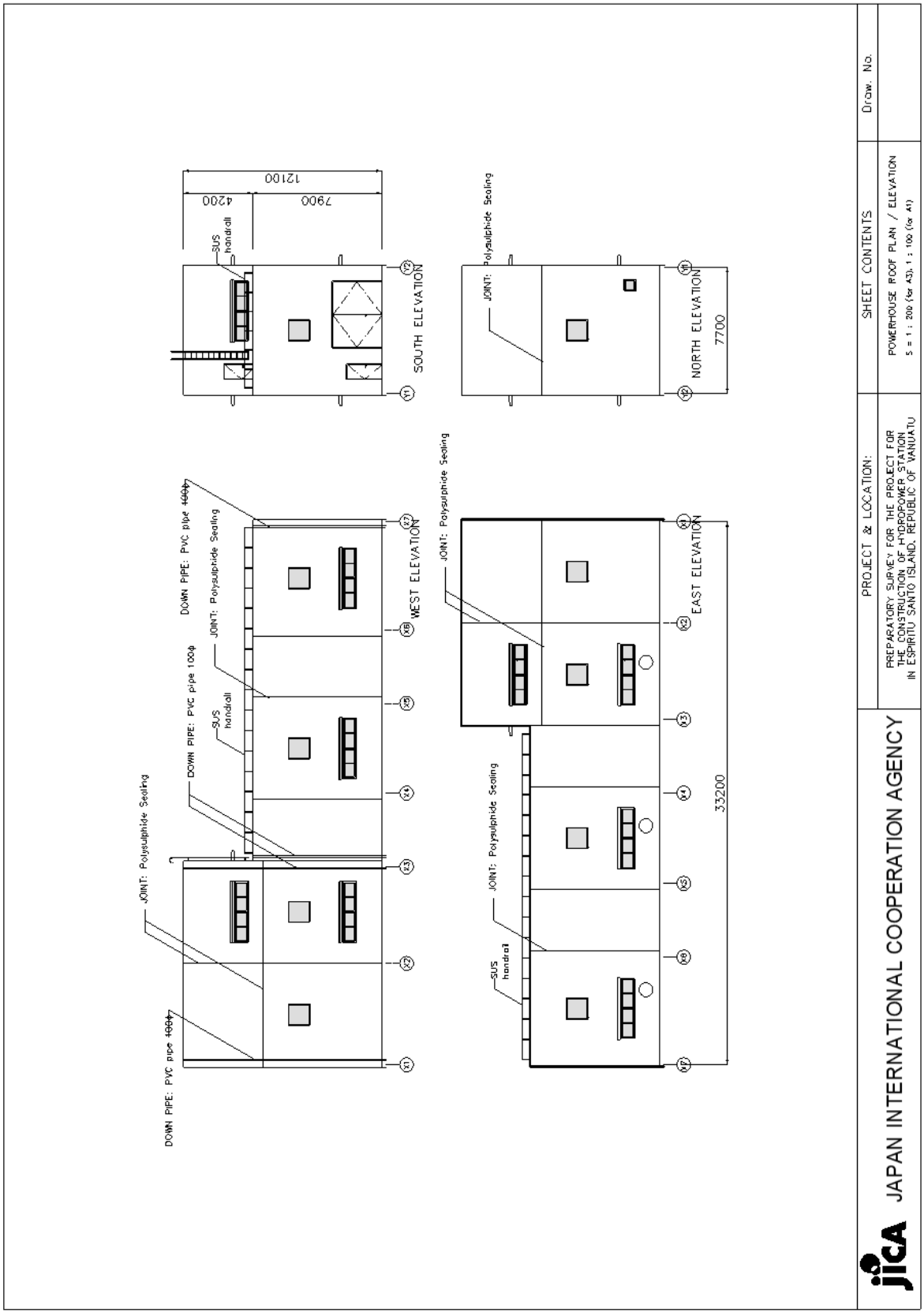


Figure 2.2-36 Elevation of Powerhouse

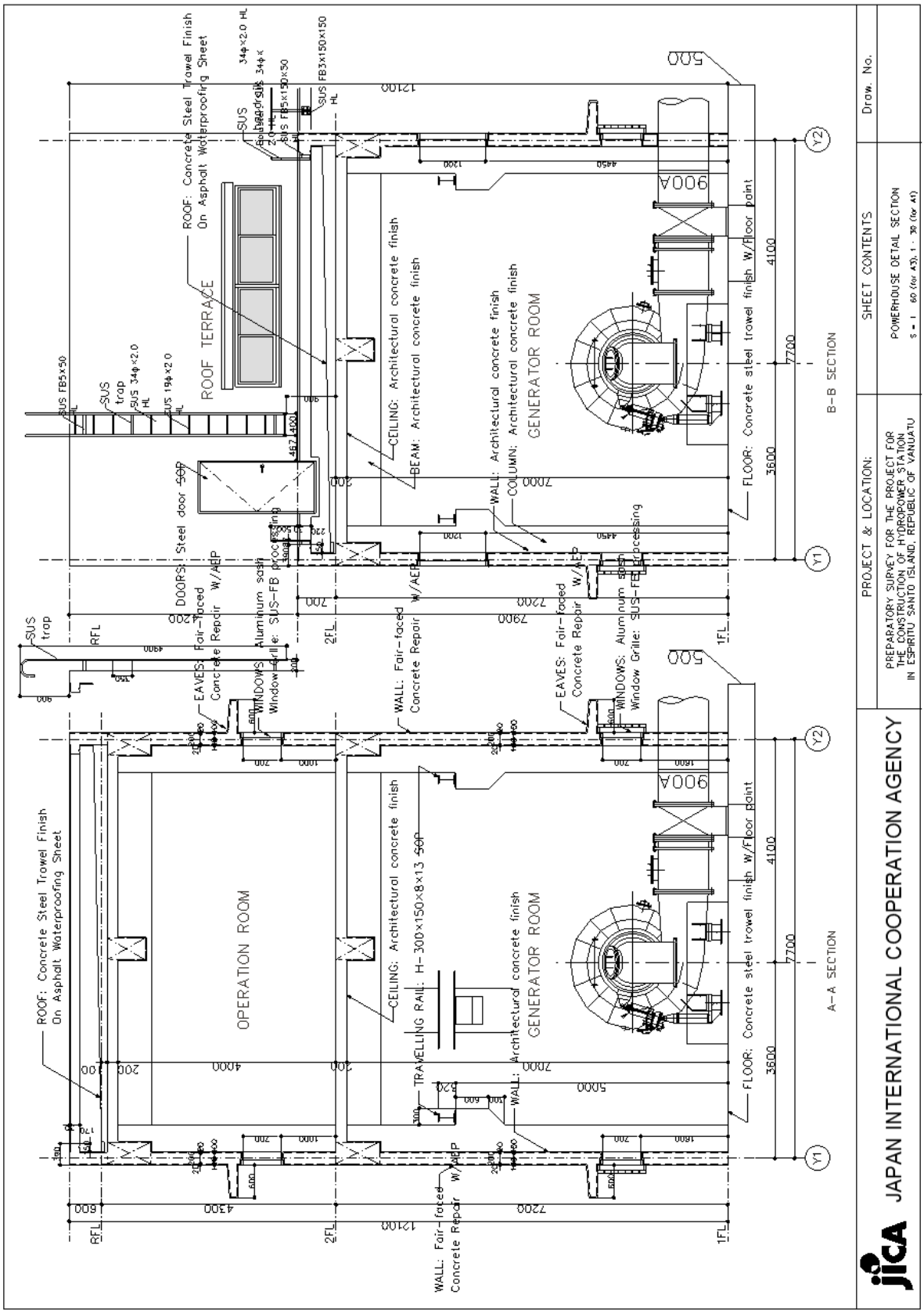


Figure 2.2-37 Detail Section of Powerhouse

2.2.3.3 Access Road

The drawings of access road are shown in Figure 2.2-38 and Figure 2.2-39.

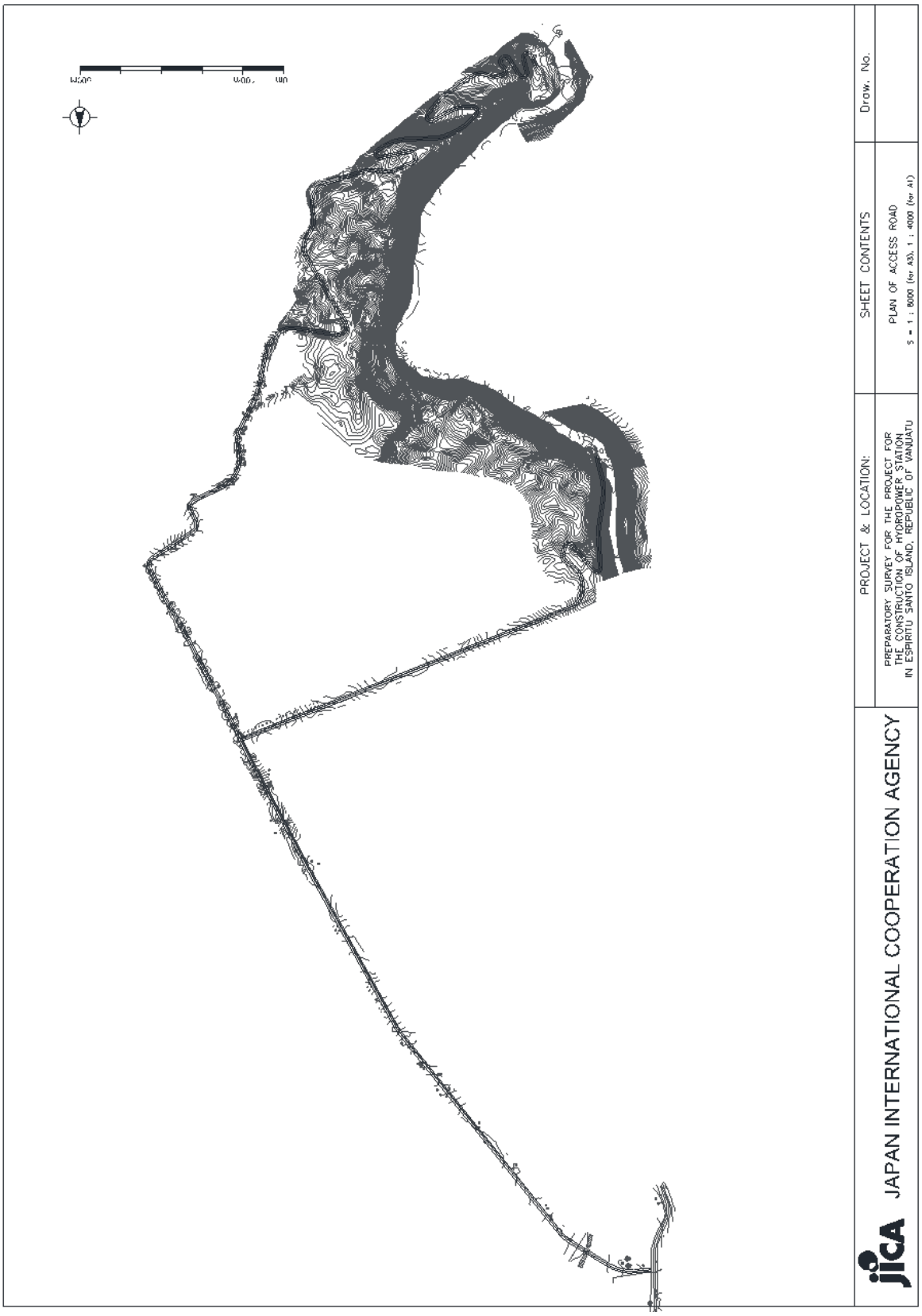


Figure 2.2-38 Plan of Access Road

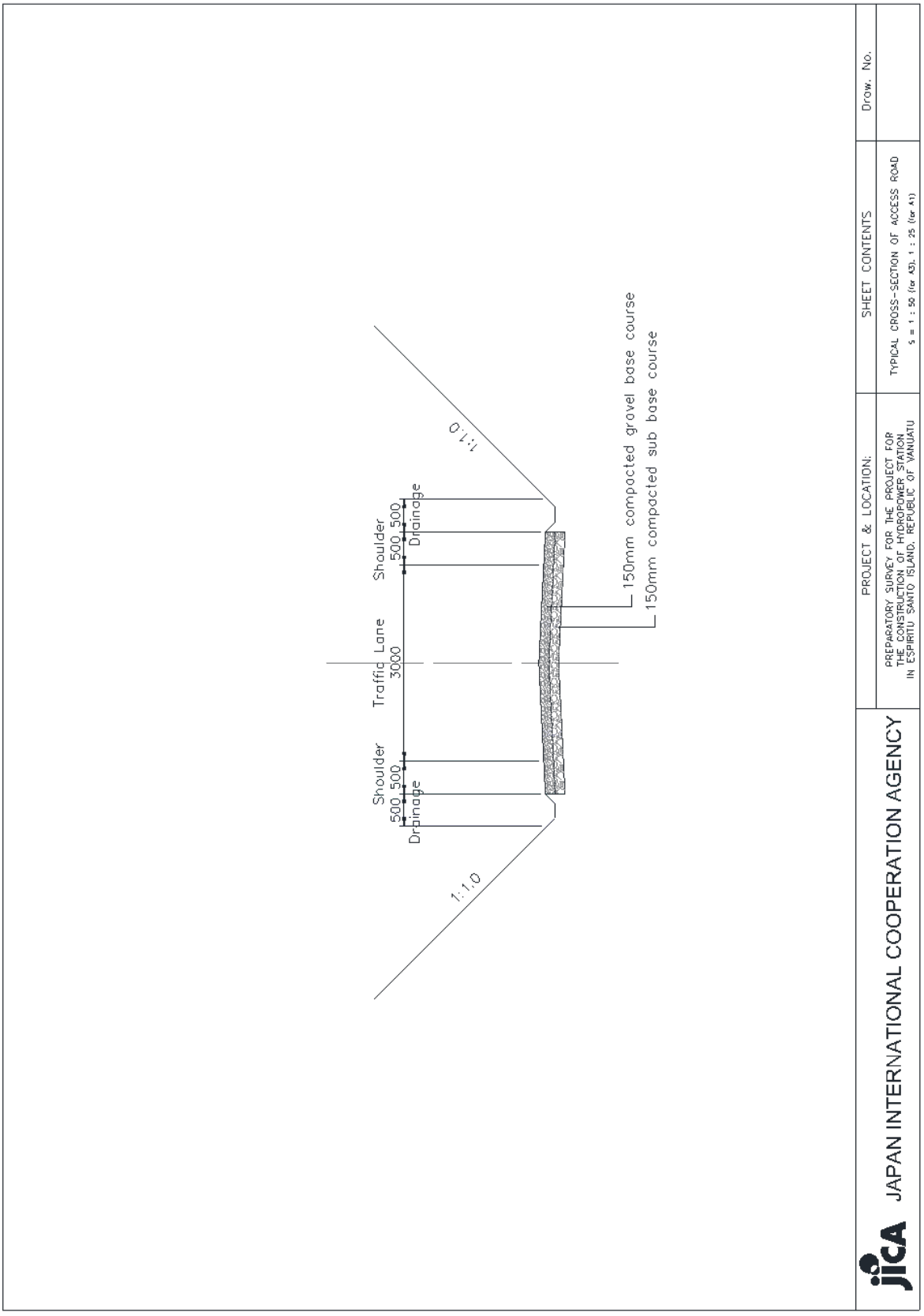


Figure 2.2-39 Typical Cross-Section of Access Road

2.2.3.4 Turbine, Generator

Outline designs of the powerhouse and turbines/generators are shown in Figure 2.2-40 to Figure 2.2-42.

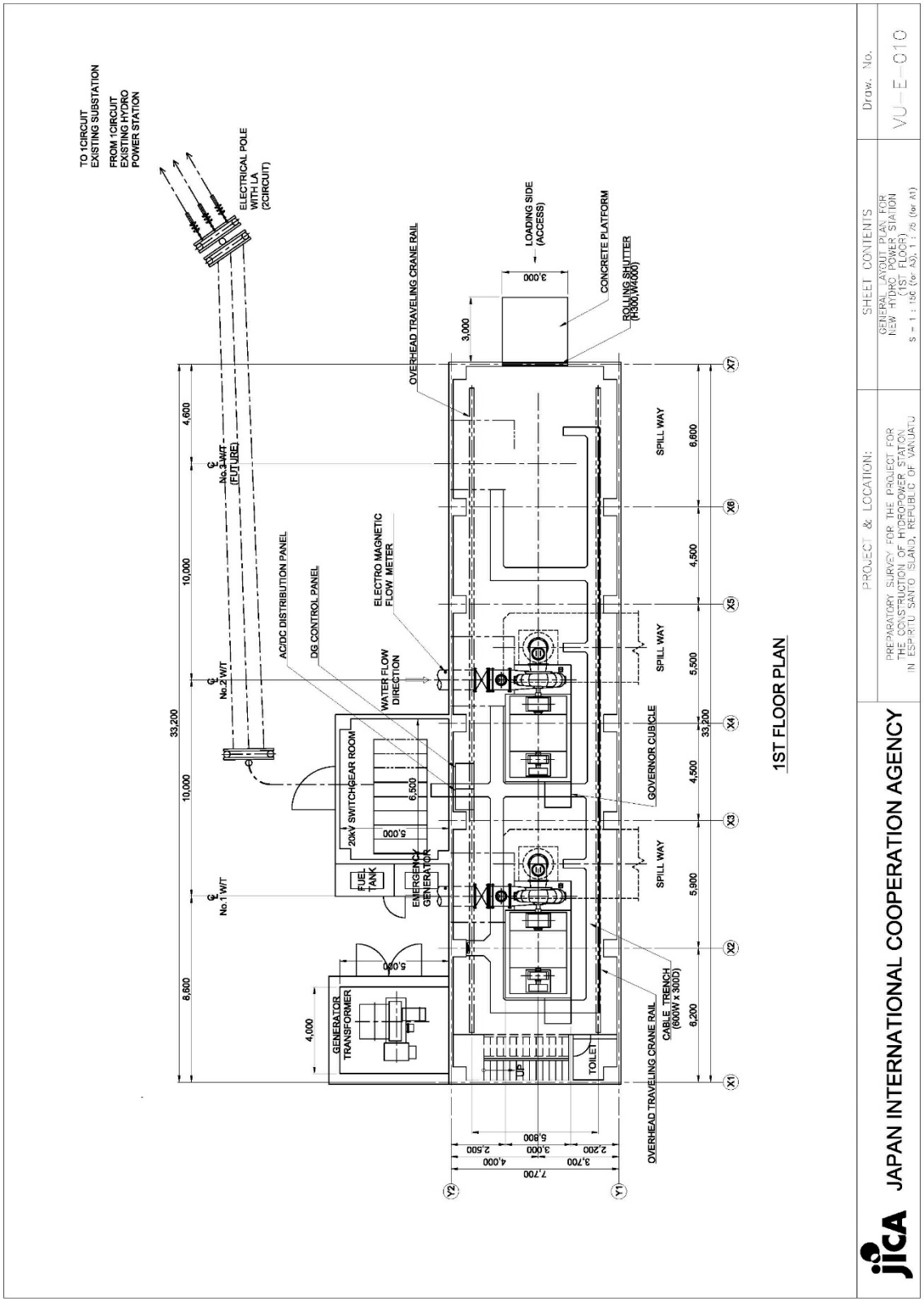


Figure 2.2-40 Layout of the New Powerhouse (1st floor)

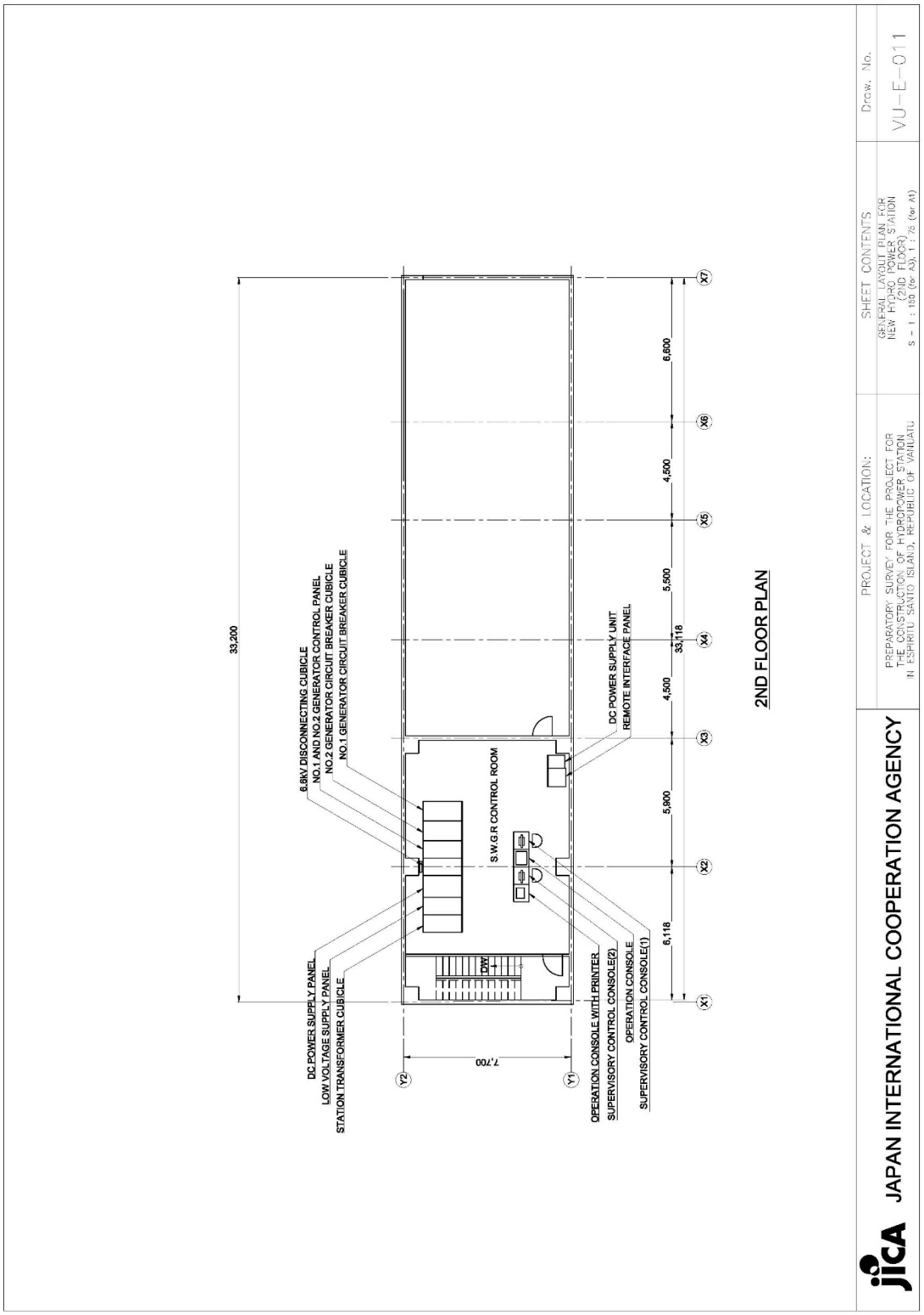


Figure 2.2-41 Layout of the New Powerhouse (2nd floor)

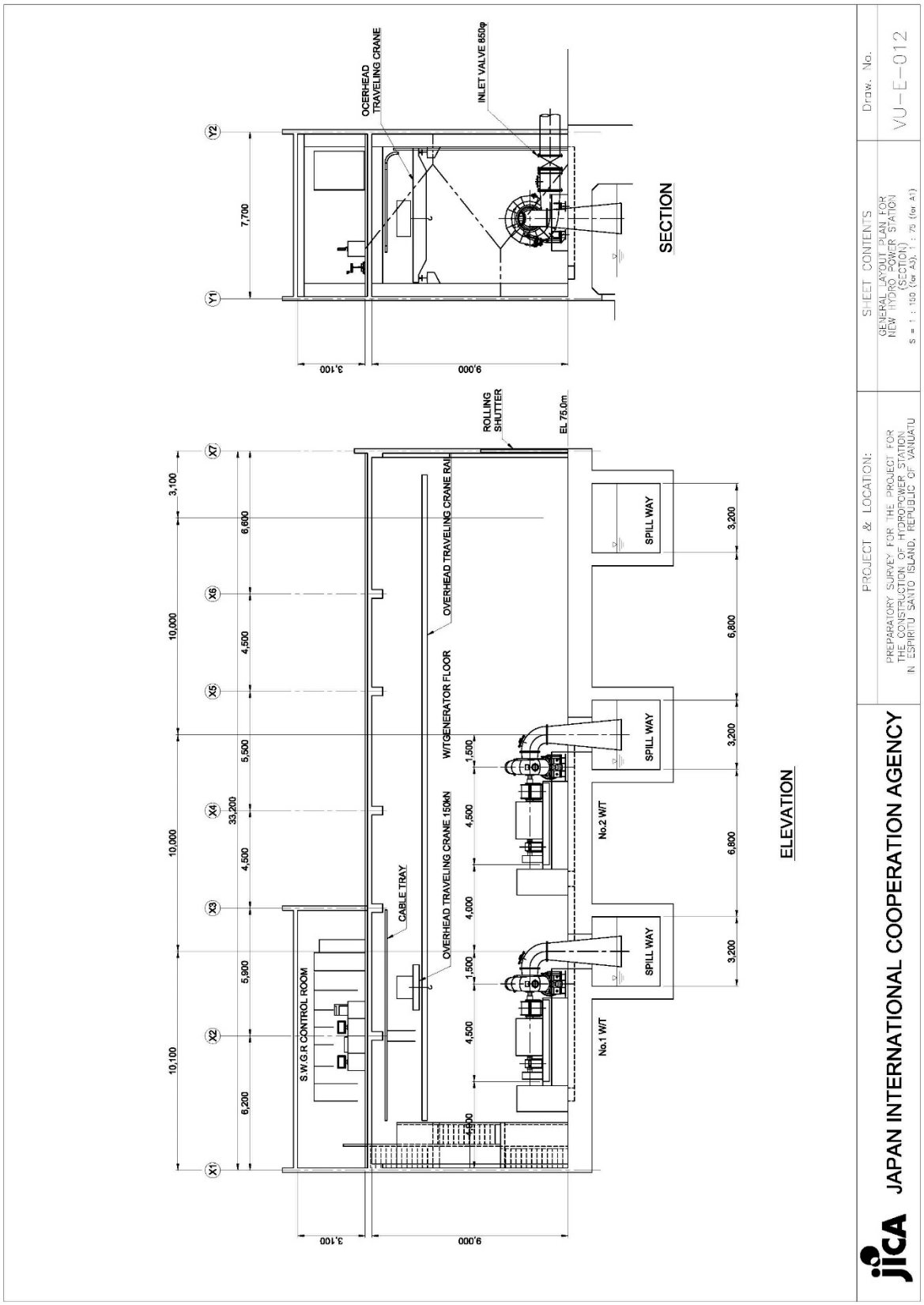


Figure 2.2-42 Side-Layout of the New Powerhouse

2.2.3.5 Power System Facilities

Outline designs of the power system facilities are shown in Figure 2.2-43 to Figure 2.2-47.

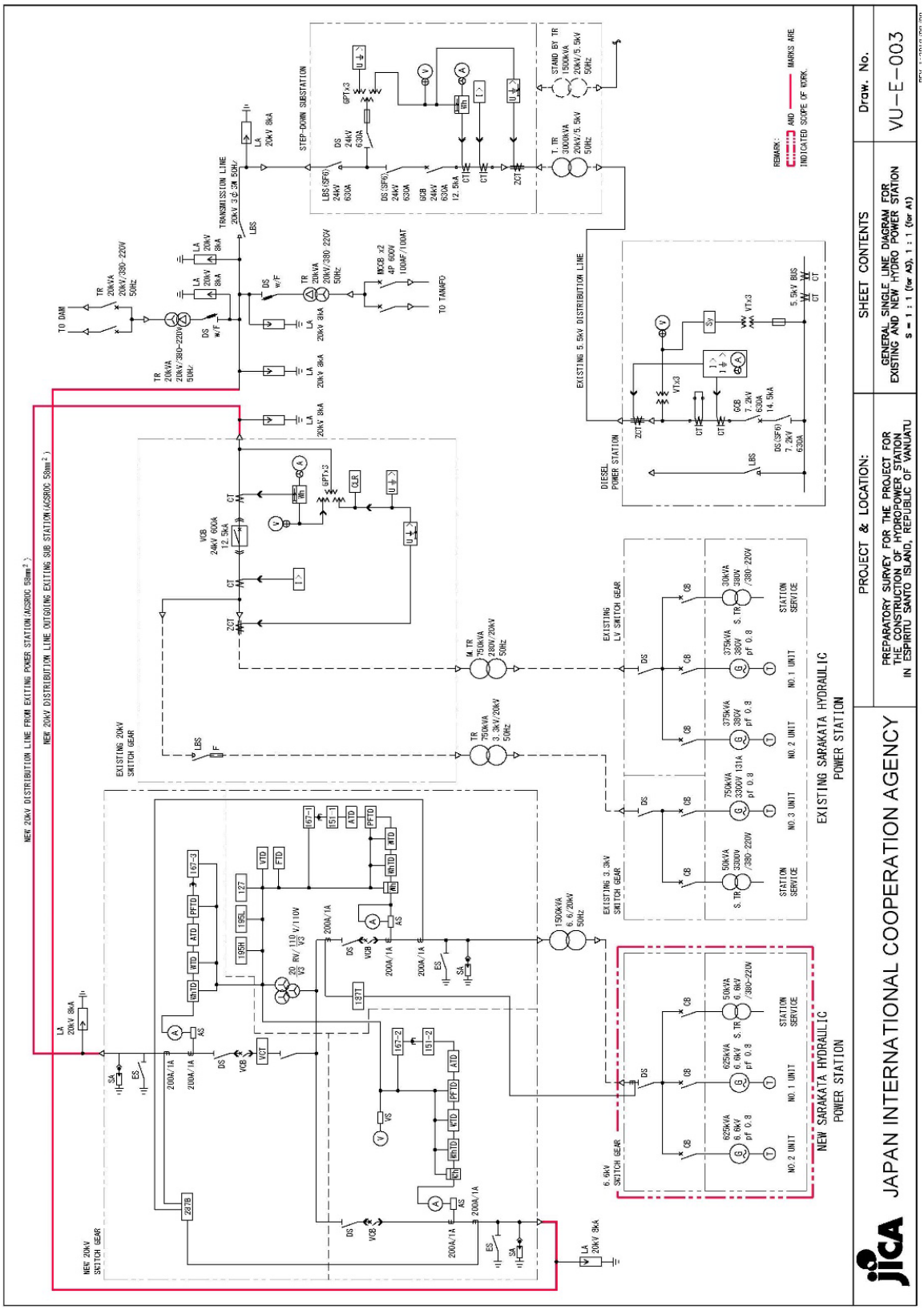


Figure 2.2-43 Single Line Diagram

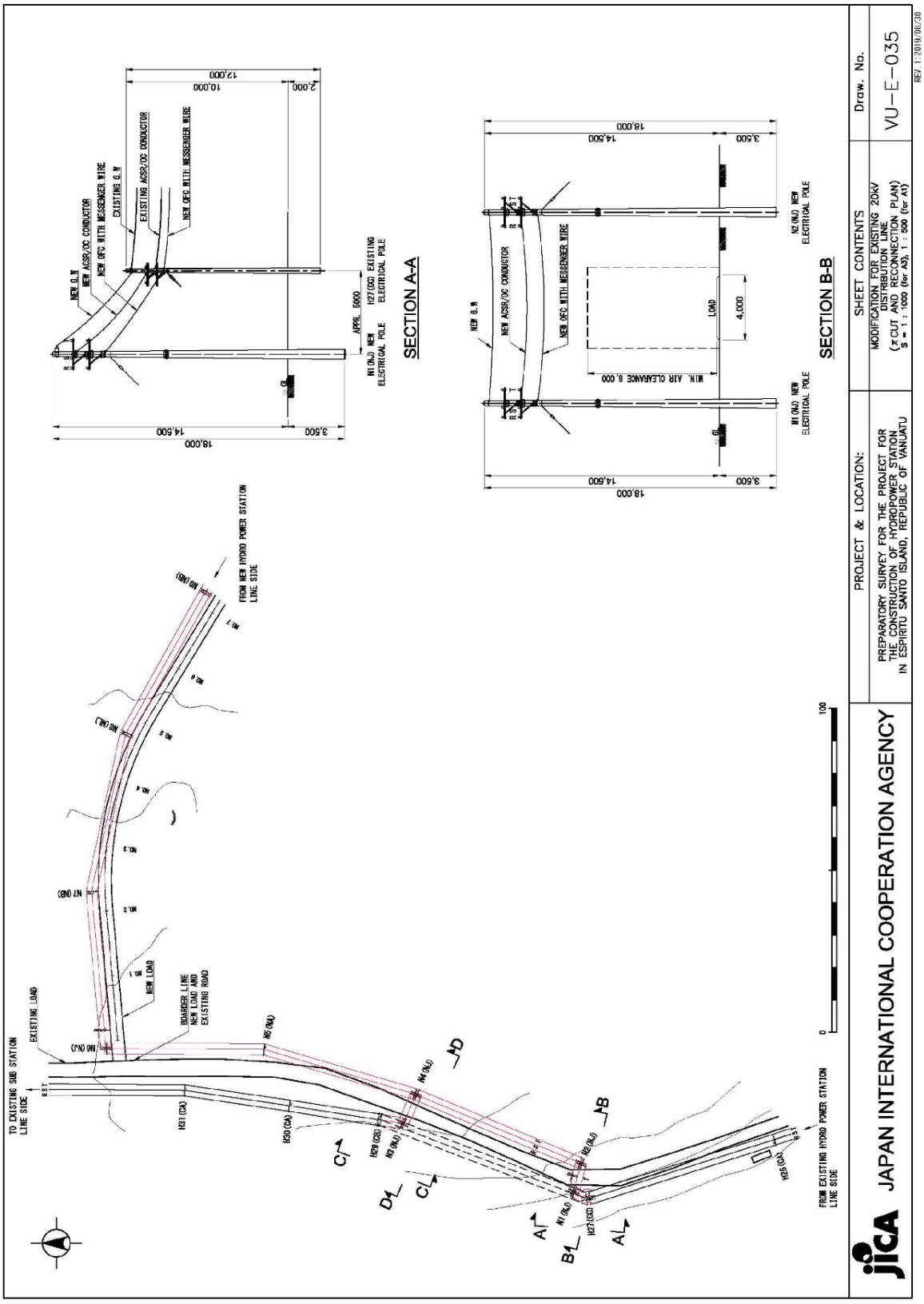


Figure 2.2-44 π (Pi) Branch Planning between existing and new Transmission Lines (1)

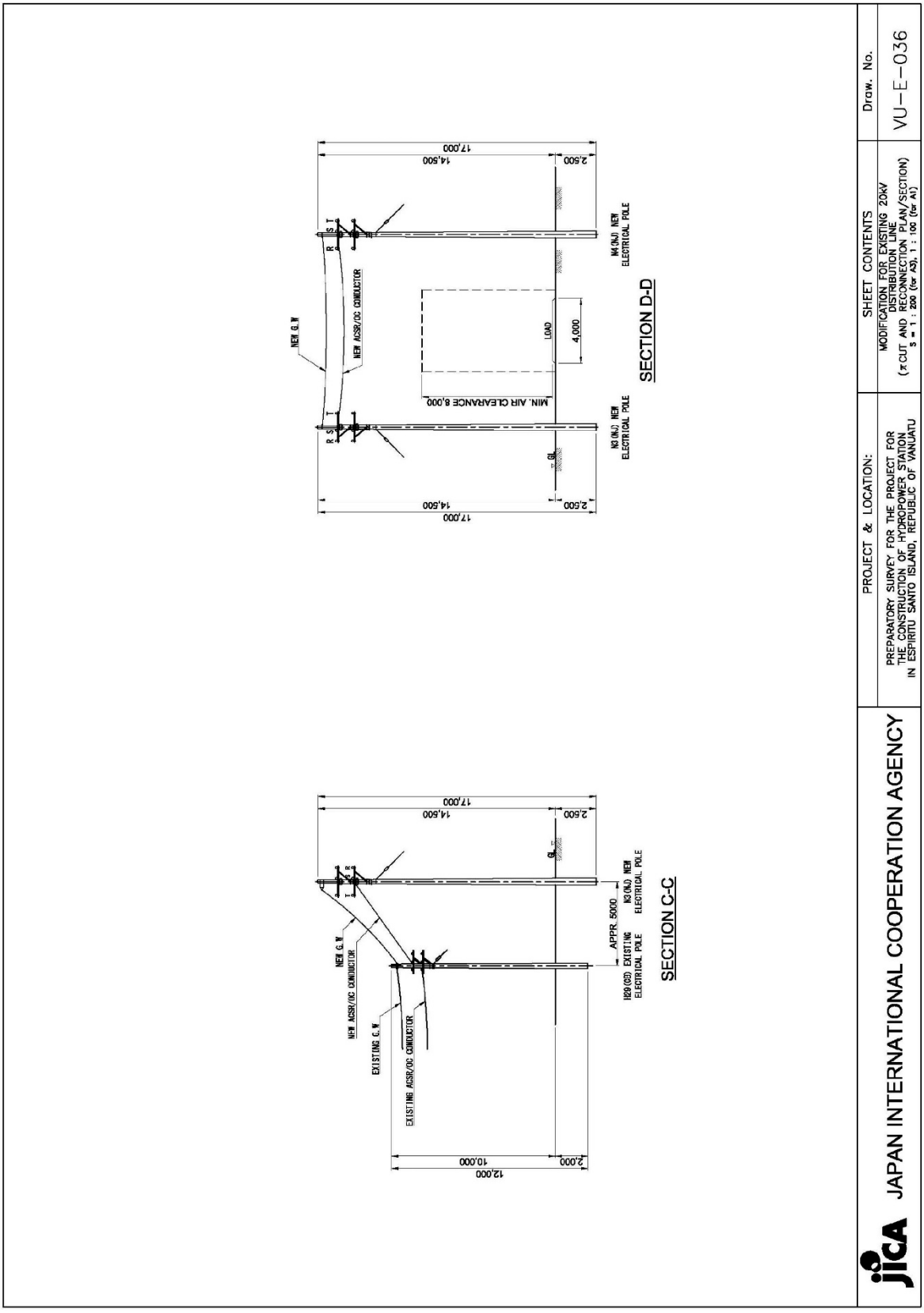


Figure 2.2-45 π (Pi) Branch Planning between existing and new Transmission Lines (2)

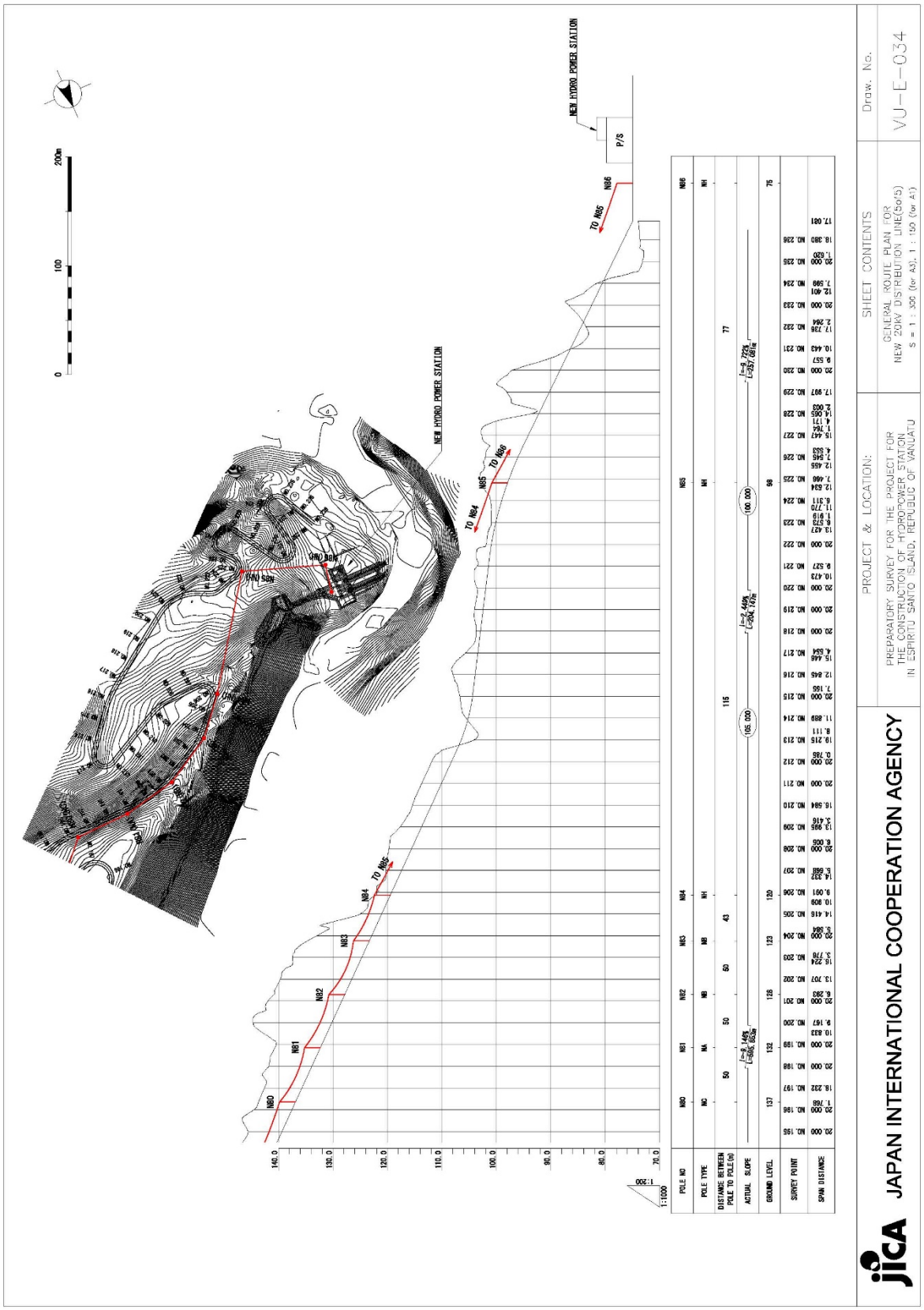


Figure 2.2-46 New Transmission Line Planning

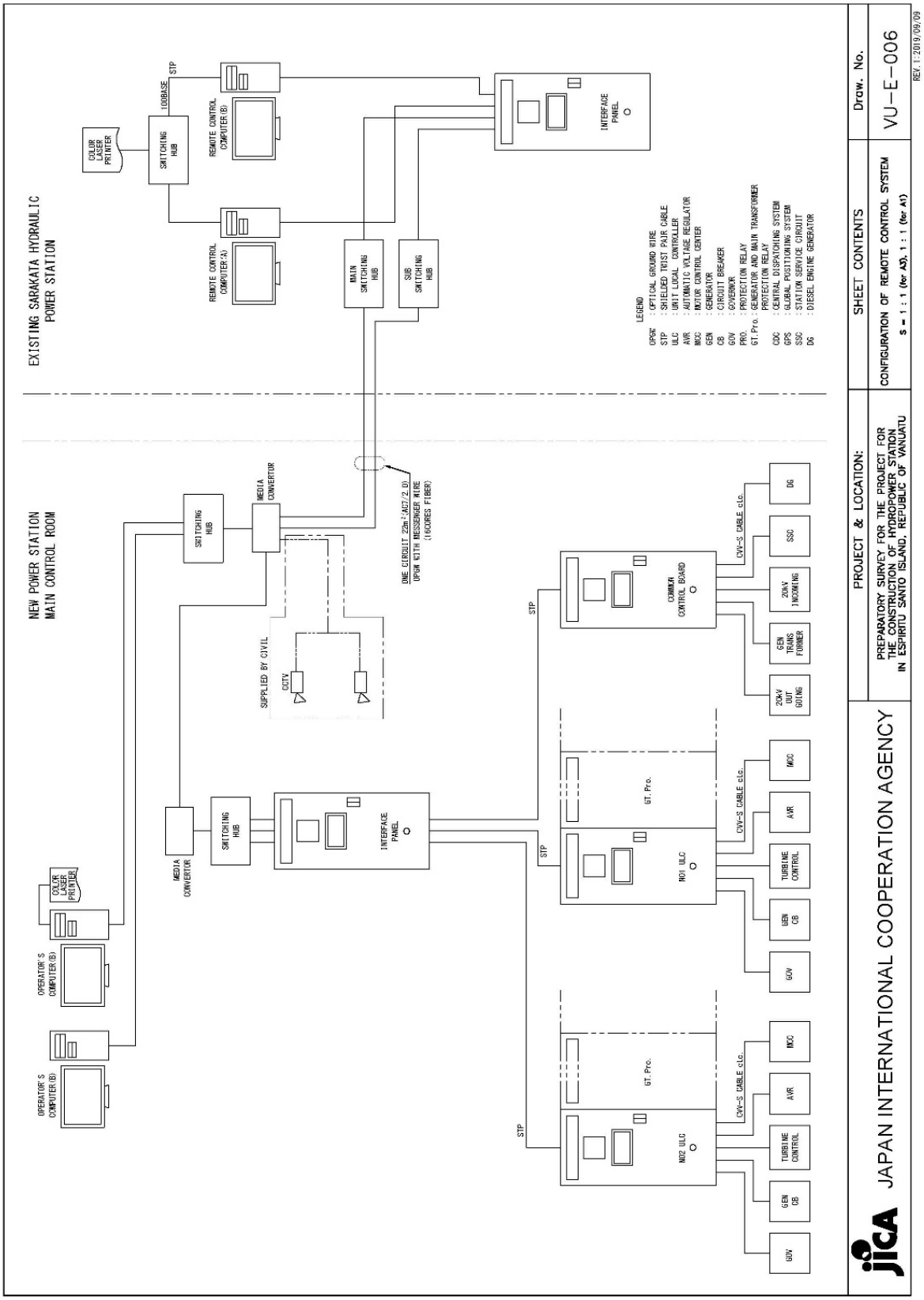


Figure 2.2-47 Configuration of Remote Control System

2.2.4 Implementation Plan

2.2.4.1 Implementation Policy

The Project will be implemented based on the exchange of notes (E/N) concluded between Vanuatu and Japan and the subsequent grant agreement (G/A) concluded between Vanuatu and JICA. The basic and special points, which need to be considered during the implementation of this project, are listed below.

(1) Project Implementation Agency on Vanuatu Side

DOE, the implementation agency of the project, will be in charge of maintaining the facilities after the completion of the project. Vanuatu Utilities and Infrastructure Limited (VUI) is a private company, and it produces and supplies electricity in Santo Island based on the concession agreement.

DOE should work closely with the Japanese consultant and the contractor to ensure the smooth progress of the project, and it has to select counterparts who will be in charge of the project and the related works. The selected counterparts of DOE should explain the project concept to the relevant staff of DOE, the related organizations and residents, and improve their understanding to promote cooperation for the project.

(2) Consultant

The Japanese consultant, recommended by JICA for the procurement and construction of the project, will conclude a contract for design and supervision with the DOE and will design, procure and supervise the project. Additionally, the Japanese consultant will prepare the tender documents and carry out the tendering on behalf of DOE.

(3) Contractors

In accordance with the framework of Japanese Grant Aid, the Japanese contractors, chosen by Vanuatu through open tendering, will carry out procurement of materials and construction of facilities required by the project. Moreover, after the completion of the project related construction, it is necessary to have after-sales service on a continuous basis to deal with break-downs and supply of spare parts. Such matters should be fully taken into consideration when stipulating the requirements in the tender contracts, especially, the communication procedure that will be implemented after the project completion.

(4) Necessity to Dispatch Japanese Engineers

This project includes construction of a new hydropower facilities such as intake facilities, powerhouse and so on, access roads, transmission lines and improvement of an existing substation. These will be constructed by different groups, so the groups have to cooperatively carry out the construction. Moreover, some of these works will be carried out in parallel, so a site supervisor who has capability to manage the entire construction activities consistently should be dispatched from Japan to conduct project schedule and cost management, quality control and safety management and installation instructors of equipment should be dispatched.

2.2.4.2 Implementation Conditions

(1) Access Conditions

The road from Luganville International Wharf to the plantation farm adjacent to the project site is paved by asphalt or macadam, however, there is no travelable road in the plantation farm and around the project site. Therefore, it will be necessary to construct new access roads in the plantation farm and around the project site. Moreover, the access road has to cross a V-shaped valley, which creates a steep slope with a height difference of about 30m, to reach the intake weir and powerhouse. Given such a topographical constraint, the road should be designed with sharp curves and steep longitudinal slopes, and therefore it is desired to set speed limits and vehicle lay-bys accordingly.

(2) Points for Construction

A cofferdam is built on a river to allow de-watering and damming of water within an enclosed area, so that the intake weir may be constructed in a dry work environment. The cofferdam will be of earth embankment type. This type is suitable for a site which has a rocky foundation and also has easy access to sufficient embankment materials. In case the earth embankment inhibits the flow of river, gabions should be used to secure the flow section, thereby reducing the sectional area of earth embankment.

The work in the river is generally carried out during the dry season for safety reasons. However if the work needs to be carried out in other seasons due to unavoidable circumstances such as a limited time-period, it can be done so, with necessary safety measures for flood.

(3) Country of Procurement for Equipment and Materials

Although cement is not produced in Vanuatu, imported cement is locally available. Local coral materials of indeterminate weight and strength are widely used in coarse aggregate for construction in Vanuatu. If the local materials are deemed unsuitable for certain structures such as reinforced concrete structures, then the import of adequate materials from neighboring countries such as Fiji should be considered. Having said that, local aggregate may be used as coarse aggregate of mass concrete and fine aggregate of both reinforced and mass concrete. Imported reinforcing bars and formwork materials are also locally available.

Not only do local companies have limited construction machinery, but there is also no rental machinery company in Vanuatu. As with materials, the construction machinery should also be procured from Japan or other countries in some cases.

Equipment for “Hydroelectric power plant”, “Substation” and “Transmission Line” are necessary for the project. These required equipment are not produced in Vanuatu and it is possible to procure from Japan or a Third country.

(4) Safety Measures

From the view of security, there are not many problems in the project site. But we need to pay attention to theft of materials and worker’s safety during construction. Hence, Japanese contractors should think of safety measures, for example setting a fence around material yard and/or deploy a guard.

Safety guides should be provided where there is a possibility of falling rock/soil to occur and

in places where workers with construction machinery.

(5) Tax Exemption

As for the tax system applicable to the project, a value-added tax of 15% and a duty custom of 0% to 30% will be applied. For this Grant Aid Project, tax exemption will be applied in accordance with the Exchange of Notes.

2.2.4.3 Scope of Works

The following table shows the aspects of construction to be borne by the Japanese and Vanuatu sides.

Table 2.2-13 The scope of works to be borne by the Japanese and Vanuatu sides

No.	Items	To be covered by Grant	To be covered by Vanuatu Side
1	To secure land necessary for the implementation of the Project and to clear the sites		○
2	To construct/procure the following facilities/equipment		
	1) Construction of facilities	○	
	2) Procurement of equipment	○	
	3) Installation of gates and fences in plantation		○
3	To provide facilities for distribution of electricity, water supply and drainage and other incidental facilities necessary for the implementation of the Project outside the sites		
	1) Electricity		
	a. Processing application for the distributing power line to the site		○
	b. Drop wiring and internal wiring within the site	○	
	c. Main circuit breaker and transformer	○	
	2) Water supply and drainage		
	a. Water supply system within the site (receiving and tanks)	○	
	b. Drainage system (for toilet sewer, common waste, storm drainage and others) within the site	○	
	3) Road		
	a. Road within the site (access road)	○	
	b. Road outside the site		○
	6) Furniture		○
4	To ensure prompt unloading and customs clearance of the products at ports of disembarkation in Vanuatu and to assist internal transportation of the products		
	1) Marine transportation of Products from Japan to Vanuatu	○	
	2) Tax exemption and custom clearance of Products at the port of disembarkation		○
	3) Internal transportation from the port of disembarkation to the project site	○	
5	To ensure that customs duties, internal taxes and other fiscal levies, which may be imposed in Vanuatu with respect to the purchase of the products and the services, are exempted		○
6	To accord Japanese nationals whose services may be required in connection with the supply of the products and the services such facilities as may be necessary for their entry into Vanuatu and stay therein for the performance of their work		○
7	To ensure that the Facilities and the products are maintained and used properly and effectively for the implementation of the Project		○
8	To bear all the expenses, other than those covered by the Grant, necessary for the implementation of the Project		○
9	To bear the following commissions paid to the Japanese bank for banking services based upon the B/A		○
	1) Advising commission of A/P		○
	2) Payment commission		○
10	To give due environmental and social consideration in the implementation of the Project.		○

Source: JICA Study Team

2.2.4.4 Consultant Supervision

In compliance with Japanese Grant Aid policy, the consultant should organize a consistent project team for actual design, management of construction and procurement based on the outline design of the preparatory survey, and should plan to carry out works smoothly. The consultant will arrange at least one on-site engineer during the procurement and construction stage. Moreover, Japanese experts should attend the manufacturing inspection at the factory and pre-shipment inspection of equipment and materials and supervise so as to prevent troubles after the arrival of equipment and materials.

(1) Basic Management Policy of Construction and Procurement

The consultant is basically supposed to manage and instruct the contractors at the work site, to carry out construction safely, verify the quality and compare the present form of the structures with the original design, and ensure the due date of procurement. It will be important to complete procurement and construction within the individual work schedules for each task, so as to complete the entire project within the overall project timeframe. Moreover, it will also be important to keep up to date on the progress of the items to be borne by Vanuatu. There are many items to be managed, i.e. procurement of equipment, temporary construction, power facility construction, road construction, building and interior work, etc. Therefore, the consultant should communicate and cooperate with the residents and contractors, and related organizations to manage the procurement and construction properly. The main points of management with respect to the construction are shown below.

1) Schedule Management

The contractors should check the actual progress, either on a weekly or monthly basis, and compare it with the schedule indicated in the contract. If any delay in the schedule is noted, the consultant should warn and instruct the contractors to submit countermeasures and urge them to take the measures to complete the procurement and construction work before the deadline. The main items for to check the progress are shown below:

① Completion and interim inspection including inspection in Factory

② Checking materials delivered to the site such as hydraulic turbine generators, etc.

③ Checking temporary work and preparation of heavy equipment

④ Checking actual working days of engineers, technicians and workers and compare it with the planned working days

2) Safety Management

The consultant will ensure - through discussions and cooperation with the contractors - site safety to prevent accidents on site and accidents to third parties from happening during the construction. The points for safety management are shown below:

① Determining safety regulations and the person in charge

② Holding a regular safety management meeting

③ Preventing accidents from happening through regular checks of heavy equipment

④ Selecting a proper route for the construction vehicles and heavy equipment, and making sure workers drive at slow speeds

⑤ Taking some measures to ensure benefit packages and encourage workers to take days offs

(2) Supervisors

Regarding the contract, Japanese contractors should employ local contractors or laborers to carry out the project. The Japanese contractors should dispatch engineers with similar work experience overseas, and the dispatched engineers should supervise the local contractors or laborers and thoroughly carry out their tasks with due adherence to time, quality and safety.

2.2.4.5 Quality Control Plan

(1) Construction of Facilities

1) Concrete

a) Concrete mix design

It is necessary to determine the concrete mix design for each nominal strength through trial mixing. As for the concrete mix design, the average compression strength of test pieces must surpass a target strength, which is set using each nominal strength, and the slump should be within a permissible range. The target strength should meet the nominal strength plus the standard deviation.

Concrete compression test is supposed to be carried out in the laboratory of the contractor or one of the local contractor. Six (6) test pieces are collected at once, and three (3) of them are used for seven (7) days compression strength test after placement (of the concrete) and the other three (3) are to be used for 28 days one after placement.

b) Concrete manufacture

There is no ready-mixed-concrete manufacturer in Santo Island. Therefore the contractors should arrange concrete plants by themselves in the project site.

c) Slump test

Slump test should be carried out for every concrete placement. The permissible range should be within ±2.5cm of the specified value.

d) Concrete compression strength test

The concrete compression strength test should be carried out by using a test machine which will be procured by the contractor or owned by local construction companies during the concrete works because there is no laboratory in Santo Island. Test pieces are collected at every placement of 100m^3 or less, and there should be three (3) test pieces for every batch.

2) Aggregates for concrete

Aggregate test for fine and coarse aggregates should be carried out to confirm the quality. All of the aggregates in Vanuatu are made from coral limestone. It should be confirmed if these aggregates have the required strength and weight. Imported aggregates will be

considered for use, if the local ones are deemed to be unsuitable.

3) Reinforcing steel bars

Tensile strength tests of reinforcing steel bars should be carried out for every diameter to be used to verify the strength. Mill sheets should be provided to check test results and quality of steel products.

(2) Procurement of Equipment

The construction supervisor of the consultant must confirm whether the quality/condition of the equipment procured by the contractors, match the technical specifications and the design drawings mentioned in the contract, by carrying out the following steps. If it does not meet the required quality and forms, the consultant should request for the modification, change, repair or replacement of the equipment.

① Verifying the technical specification and the shop (manufacturing) drawings of equipment.

② Attending the inspection of equipment at the factory or verifying the report of the results of factory inspection

③ Verifying the way of packing, transporting and storing of equipment.

④ Verifying the construction (working) drawings and the installation manual for equipment

⑤ Verifying the inspection manual, the way of commissioning and adjustment of equipment at the factory and site.

⑥ Supervising installation of equipment and attending commissioning, adjustment and inspection

⑦ Verifying the finished site form of the equipment and comparing it with the installation and shop (manufacturing) drawings

⑧ Verifying as-built drawings

2.2.4.6 Procurement Plan

Japanese products have been in operation at the existing Sarakata river hydropower plant in Santo Island. Considering the compatibility of operation and maintenance, the equipment to be procured in this project including the hydropower equipment, SCADA, equipment and materials for the transmission line and the substation equipment are expected to be Japanese products. The following table shows the countries involved in the procurement of equipment for this project.

Table 2.2-14 Procurement of equipment

Items	Country of origin			Reasons for procurement place	Procurement ways
	Vanuatu	Japan	Third countries		
Hydraulic turbine generator		○		For comprehensive operation and maintenance	Marine transportation from Japan
Distribution equipment		○		For comprehensive operation and maintenance	Marine transportation from Japan
Substation equipment		○		For comprehensive operation and maintenance	Marine transportation from Japan
SCADA		○		For comprehensive operation and maintenance	Marine transportation from Japan
Transmission line		○		Not locally available	Marine transportation from Japan

Some construction materials will be procured from Japan or other countries, since the local market has limited materials. The following table shows the countries involved in the procurement of construction materials for this project.

Table 2.2-15 Procurement of construction materials

Items	Country of origin			Reasons for procurement place	Procurement ways Vanuatu
	Vanuatu	Japan	Other countries		
Cement	○				
Reinforcing bar	○				
Formwork material	○				
Coarse aggregate	○		○	Depending on the required quality	Marine transportation from Japan or other countries
Fine aggregate	○				
Penstock		○		Not locally available	Marine transportation from Japan
Gate and screen		○		Not locally available	Marine transportation from Japan
Steel door and aluminum sash		○		Not locally available	Marine transportation from Japan

2.2.4.7 Initial Operation and Maintenance Guidance Plan

(1) Purpose

The new hydropower plant is planned to be operated by means of remote control system from the existing hydroelectric power plant. This is the first time DOE and VUI are installing this operation system, so the contractor will guide the operators and maintenance staff, who are to operate and maintain the new plant, regarding the initial operation and maintenance, in order to maintain the hydropower plant facilities in proper operation and promptly respond to incidents.

(2) Initial Operation and Maintenance Guidance Plan

After the construction of hydropower facilities, transmission line facilities and substation facilities are completed, the contractor will conduct practical training in matters such as start and stop of operation, operation in case of emergency, daily patrol, maintenance is to be

conducted by the manufacture to the operators and maintenance staff in the presence of the consultant. The training should be conducted using the operation and maintenance manual of this system prepared in English.

The contents of the training plan are shown below.

1) The implementation period and the location of technical training

Lecture and practical training: About two (2) weeks (on-site)

2) The Instructors

The instructors shall be engineers in charge of equipment installation/testing/adjustment and shall be dispatched from the manufacturer of the hydropower equipment (turbines, generators, control system, switchboards, etc.) delivered by the contractor.

3) Trainees

The trainees of VUI side who will receive technical training are the following operators and maintenance personnel, who will be directly involved in the operation and maintenance work once the operation of hydropower plant is commenced.

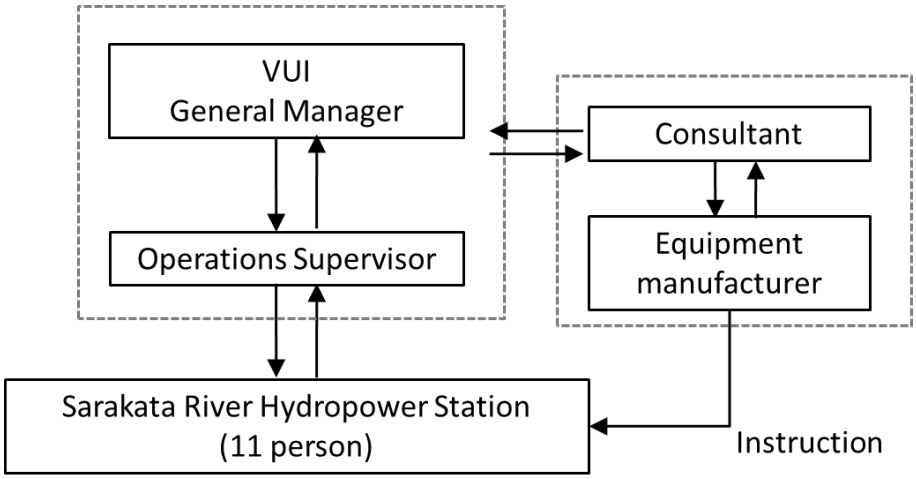


Figure 2.2-48 Organization Chart for Operation and Maintenance of Hydropower Station (Draft)

4) Training content

a) Class-room lectures

The following topics of the hydropower plant will be covered in the lectures by using the operation and maintenance manual.

- Explanation regarding the general contents of operation and maintenance manual
- Basics of operation/maintenance method, equipment functions, basics of accident/ fault countermeasures, management of spare parts and tools, management of drawings, documents
- Transmission line system

- Turbine and generator equipment (functions of turbine generator and its peripheral equipment, operation of control panel, operation stop, emergency stop)
- Operation by remote control system (turbine operation by remote control system, operation method, data handling)
- Maintenance of turbine and generator
- Operation and maintenance of switchboard

b) On-the-job training

The following training topics will be covered on site during the equipment installation and commissioning.

- Function explanation and operation of turbine equipment (turbine, generator and its peripherals, operation of control panel, start and stop of operation, emergency stop)
- Basics of operation/maintenance of equipment, equipment functions, basics of accident/fault countermeasures, management of spare parts and tools, management of drawings, documents)
- Remote operation (turbine operation by remote device, management method, data handling)
- Maintenance of turbine and generator
- Operation and maintenance of switchboard
- Maintenance of transformer
- On-site explanation of panel meters and parts
- Method of monitoring, visual inspection
- Method of maintaining the electric facilities

2.2.4.8 Soft Component (Technical Assistance) Plan

(1) Background for Planning Soft Component

The Sarakata River hydroelectric power plant of 300kW × 2 units was constructed from 1994 to 1995 and expansion power plant of 600kW × 1 unit was constructed in 2009 as the Japanese Grant project. The Sarakata River hydroelectric power plant of 1,200kW had been contributing to stable power supply as the main power source in Luganville power system, Santo Island. However, the existing Sarakata River hydroelectric power plant alone could not cover the electricity demand in Santo Island, where daytime peak load reached 1,932kW in 2016. Therefore, power supply in Santo Island had been covered with the diesel power plants which depend on expensive import fuel. The electricity demand has been growing in Santo Island and the future power demand is forecasted to increase surely. So, assuming the present power source mix the dependence on the diesel power plants is expected to grow.

Operation, maintenance and management of power plants and distribution facilities is done by means of consignment contract to private sectors i.e. a concession system under the supervision of DOE, department concerning power generation and distribution in Vanuatu

In the Luganville concession area in Santo, the electricity supply business is managed by Vanuatu Utilities and Infrastructure Limited (VUI). VUI employees operate and maintain the

existing Sarakata River hydroelectric power plant.

Some of the VUI employees, who are in charge of the power plant, participated in the operation and maintenance (O&M) training conducted by the manufacturer and consultant in 1995 during the construction and have been engaged in this power plant. In 2009, expansion of the power plant and a large-scale repair works on open channel and slop protection works were carried out. Every year, accidents of distribution lines and damaged of facilities occurs, but so far there has been no serious accidents resulting in a blackout, and the restoration work has been carried out by VUI employees.

The new hydroelectric power plant is to be operated from the existing Sarakata river hydroelectric power plant by means of automatic operation and remote control method. Therefore, it is very important to carry out the training to deal with malfunctions, troubles, accidents of facilities, transmission lines and so on. Also, it is necessary to conduct optimum operation of five (5) units of hydroelectric power plants in order to reduce the consumption of diesel fuel. Also, serious accidents can be prevented by conducting daily and weekly patrol of civil facilities, electro-mechanical equipment and transmission line.

In addition assistances to the side who regulates business operation, capacity building to the side who carries out operation and maintenance of the new hydroelectric power plant is effective to conduct repairs, countermeasures in case of accidents and troubles and so on appropriately, to reduce the risks, to secure the sustainability of business efficiency is expected. It is also expected to obtain the effects of technical transfer for longer period because of long i.e. twenty (20) year concession period.

(2) Objective of Soft Component

VUI, which manages the power supply business under the concession system, shall establish a sustainable management system for proper operation, maintenance and management of the new power plant, in addition to the optimum operation of the existing Sarakata River power plant. As a result, reduction of electricity fee is to be achieved by maximizing the reduction of the fuel consumption.

(3) Achievement of Soft Component

Each outcome is confirmed by the following method, and the report is prepared as deliverable. Specific indicators shall be determined, in consultation with DOE, by the time the soft component is commenced.

a) Establish proper methods for the inspection and maintenance of generation equipment

b) Establish proper methods for inspection and maintenance of civil facilities

c) Strengthen optimum operation of the existing and the new hydroelectric power plants and strengthen the ability to deal with malfunctions, troubles and accidents.

d) Establishment of Monitoring System

(4) Confirming Achievement of Soft Component

Technical transfer is done for each activity and the confirmation results are described in the activity report.

Table 2.2-16 Output and Confirmation Method of Soft Component

Item	Output	Confirmation method
Operation, inspection and maintenance for generation equipment	Inspection and maintenance manual for generation equipment	Check whether the procedures and contents are understood based on the manual.
	Daily operation record	Check daily operation record
	Daily inspection record	Check daily inspection record
	Ledger of facility, spare parts and equipment	Check relevant ledger
Inspection and maintenance of civil facilities	Inspection and maintenance manual for civil facilities	Check relevant manual
	Daily inspection record	Check daily inspection record
	Maintenance record	Check repair and maintenance record
Optimum operation for the existing and the new hydroelectric power plant	optimum operation scheme of the existing and the new hydroelectric power plants	Check understanding level of optimum operation scheme
Response in case of accidents and emergencies in generation equipment, transmission line and substation facilities	response manual in case of accident and emergency	Check of the ability to deal with accidents and emergencies in the generation equipment, transmission line and substation facilities.
	Contact list to be used at the time of equipment fault	Check the contact list
Middle and long term maintenance plan	Plan of overhaul and replacement of major parts and Budgetary plan	Check the replacement schedule of generation equipment and budget plan
Monitoring System and method	monitoring system and method for monitoring generation equipment, transmission line and substation facilities	Check the system and monitoring forms
	monitoring of electricity bill and green energy fund and periodic reporting	Check the system and monitoring forms

(5) Activity on Soft Component (Input Plan)

To achieve the above-mentioned four (4) accomplishments, the following activities are implemented.

Prior to the conduct of soft component, the Contractor and the manufacturer will provide guidance for the initial operation of facility and equipment and will explanation about the maintenance method.

Soft component shall be carried out in order to support and strengthen the capability of operation, inspection and maintenance of generation equipment, civil facilities transmission line and distribution facility, optimum operation of the existing and new hydroelectric power plants, ability to deal with accidents and emergencies and to establish monitoring system of DOE, to operate a new hydroelectric power plant smoothly, to realize optimum operation of the existing and the new power plant and ensure sustainable operation, maintenance and management.

The manufacture prepares detailed operation and maintenance manual of each equipment.

Realization of optimum operation of existing and new power plants response and strengthening of capability in case of accidents and emergency cannot be achieved by using manufacture's manual.

Maintenance to be carried by the VUI staff in the soft component is daily inspection and minor maintenance works. Large scale overhaul and replacement of major spare parts shall be done by the manufacturer in accordance with the established middle and long term plan. Preventive maintenance system is established to grasp the current condition of generation equipment and facilities.

1) Establish proper methods for inspection and maintenance of generation equipment

Work Items	Method
1) preparation of Inspection and maintenance manuals for generation equipment	Prepared in Japan
2) On-the-Job Training (OJT) by using the manual	OJT of operation by using the manual
3) daily operation record	Operator prepares operation record through OJT and as a result of OJT, revision and correction of forms are done
4) maintenance and repair records	Maintenance staff prepares maintenance and repair records through OJT, and as a result of OJT revision and correction of forms are done
5) preparation of Ledger of facility, spare parts and equipment	Maintenance staff prepares the ledger through OJT, and as a result of OJT, revision and correction of forms are done

2) Establish proper methods for inspection and maintenance of civil facilities

Work Items	Method
1) preparation of Inspection and maintenance manuals for civil facilities	Prepared in Japan
2) OJT by using manual	Maintenance staff carries out daily inspection of civil structures by using the manual prepared through OJT
3) daily inspection records	Maintenance staff prepares daily inspection records through OJT, and as a result of OJT, revision and correction of forms are done
4) maintenance and repair records	Maintenance staff prepares maintenance and repair records through OJT, and as a result of OJT, revision and correction of forms are done

3) Strengthen optimum operation of the existing and new hydroelectric power plants and strengthen the ability to deal with malfunctions, troubles and accidents

Work Items	Method
1) formulation of optimum operation scheme of existing and new hydroelectric power plants	Check Optimum operation scheme

Work Items	Method
2) application of optimum operation	On-the-job training for each case study is carried out in accordance with optimum operation scheme
3) Prepare response manual in case of accident and emergency	Check the response manual Contact list at the time of equipment fault
4) On-the-job training for each case study by using the manual	On-the-job training for each case study is carried out
5) Middle and long term maintenance plan	Overhaul schedule and replacement schedule of major parts are prepared.

Remarks: activities 1), 2), 5) in charge of Advisor of Optimum operation/ Maintenance for generating equipment
activities 3), 4) in charge of both advisors

4) Establishment of Monitoring System

Work Items	Method
1) Periodic monitoring system and method for generation equipment, transmission line and substation facilities	Effective monitoring system and methods for monitoring are to be discussed with the related organization and established. Preparation of monitoring form is supported by OJT.
2) Periodic monitoring of electricity bill and green energy fund	Effective monitoring system and periodic reporting are to be discussed with the related organization and established

(6) Procuring Implementation resources of Soft component

This soft component is to be conducted directly by four (4) experts of Japanese Consultant (Team Leader/ Advisor for optimum operation, Advisor of Optimum operation/ Maintenance for generating equipment, Advisor of Maintenance for transmission line and substation facilities and Advisor of Maintenance for civil facilities). Sub-contact of local resources is not implemented. The reasons is as follows.

(1) There are no appropriate human resources who satisfy with required technical level.

(2) It is necessary to be carried out by the Japanese consultant who conducted basic design of automatic operation by using remote control from the existing hydroelectric power plant.

(3) It is necessary to arrange several experts of Japanese consultant who conducted design of generating equipment, transmission line and substation facilities and civil facilities of the new hydropower plant.

(7) Implementation Schedule of Soft Component

This Project is implemented within a period of 51 months after the conclusion of Exchange of Notes (E/N). Construction period is estimated to be about 43 months including the procurement, construction of facility, transportation of equipment and materials, installation, wet and dry test and trial operation.

Prior to the commencement of construction, E/N, consultant's contract, detailed design, preparation of bidding documents, bidding, bid evaluation, and contractor's contract shall be concluded. Overall implementation schedule and detailed schedule of Soft Component are shown in Table 2.2-19 and Table 2.2-20, respectively.

(8) Deliverable of Soft Component

Deliverables of soft component are as listed below

Table 2.2-17 Deliverable of Soft Component

Items	Time for submission
1. Completion Report	After completion of construction
2. Actual Status Report	After conducting the training(including the result of On-the-Job Training)
3. Inspection and maintenance manuals for generation equipment, transmission line and distribution facility (including daily operation record, maintenance and repair records,	After completion of construction
4. Inspection and maintenance manuals for civil facilities	After completion of construction
5. response manual in case of accidents and emergencies	After completion (including inspection, maintenance record and countermeasure at emergency)
6. Operation scheme of the existing and the new hydroelectric power plant	After completion of construction
7. Periodic Monitoring form of generation equipment, transmission line and distribution facilities	After completion of construction
8. Ledger of Facility and Spare Parts	After completion of construction
9. Middle and Long Term Maintenance Plan (including budget plan)	After completion of construction

(9) Obligation of the Implementing Agency at Vanuatu

Target of technical transfer for the soft component is VUI employees. Organization of operation, maintenance and management of two (2) hydroelectric power plants consists of existing ten (10) staff. It is necessary to discuss with VUI whether it required to hire additional / new staff to manage the new hydroelectric power plant.

(a) Operator and maintenance staff required for operation, maintenance and management of the new hydroelectric power plant shall be secured.

(b) Responsible persons such as operator and maintenance staff of VUI and the counterpart at DOE and the URA staff required for the implementation of soft component shall be secured. Operator, maintenance staff of VUI who get trained in technology shall continuously work at the hydroelectric power plant.

(c) The staff who are second in the line of operation and maintenance of power plant shall be trained.

(d) Continuous monitoring system shall be established and the budget shall be secured by DOE

(e) Financial support shall be provided by the government of Vanuatu to deal with large scale accidents, natural disaster, etc.

Feasibility of these responsibilities, assumed disincentive and required measures in case of disincentive are summarized in the following table.

Table 2.2-18 Responsibility of Vanuatu, Assumed Disincentive and Required Measures of Sustainable Operation and Maintenance.

	Feasibility for these responsibility	Assumed disincentive	Required measures in case of disincentive
(a)	Secure operators and maintenance staff required for the operation, maintenance and management of the new power station.	It is planned that a total of ten (10) staffs will operate, maintain and manage the new power station. However, they cannot do so due to overwork.	Additional staff
(b)	Operators and maintenance staff who have learned the techniques work continuously	Job change and retirement of the existing operator and maintenance staff	Reflect employment plan of VUI
(c)	Staff who are second in line in the operation and maintenance are trained and developed		Reflect employment plan of VUI
(d)	Establishment of sustainable monitoring system and securement of budget for DOE and URA	Shortage of staff, shortage of budget	Make a schedule in advance in order to solve manpower shortage and secure the budget.
(e)	Large scale accidents, disasters such as hurricanes, earthquakes etc.	During large-scale accidents which causes black out, VUI by itself cannot restore the damaged equipment and facilities.	Financial support from government JICA Follow-up

Table 2.2-19 Detail Section of soft Component (Draft)

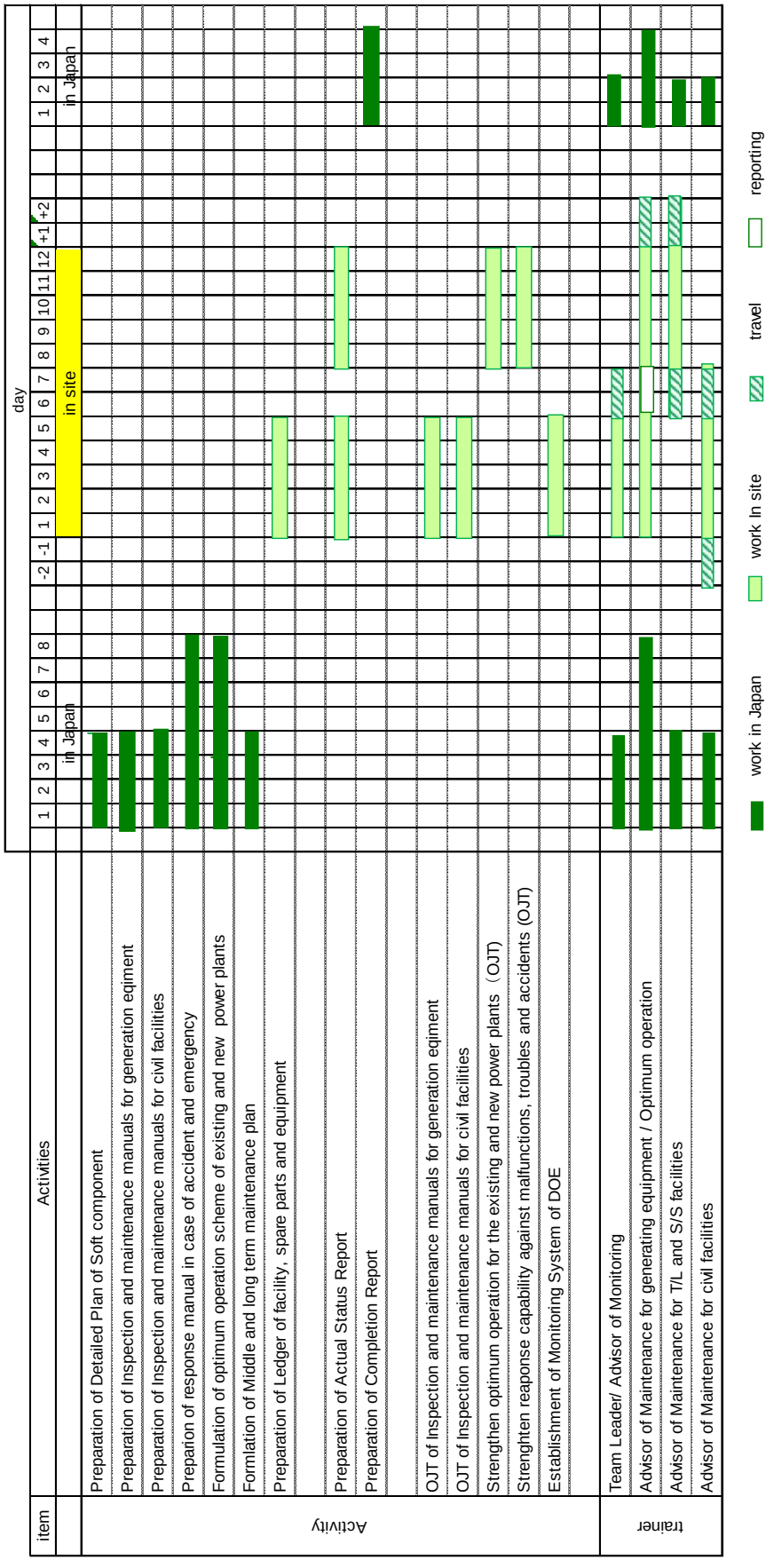
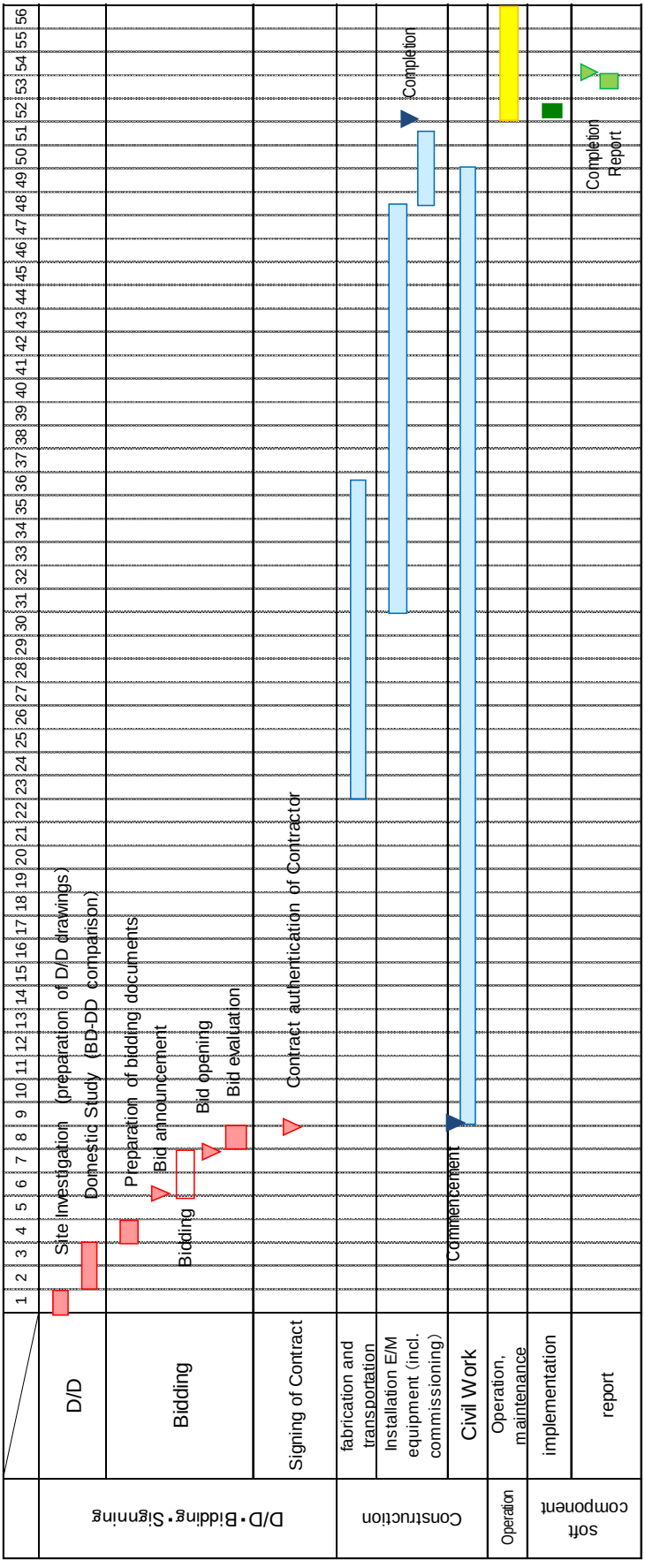


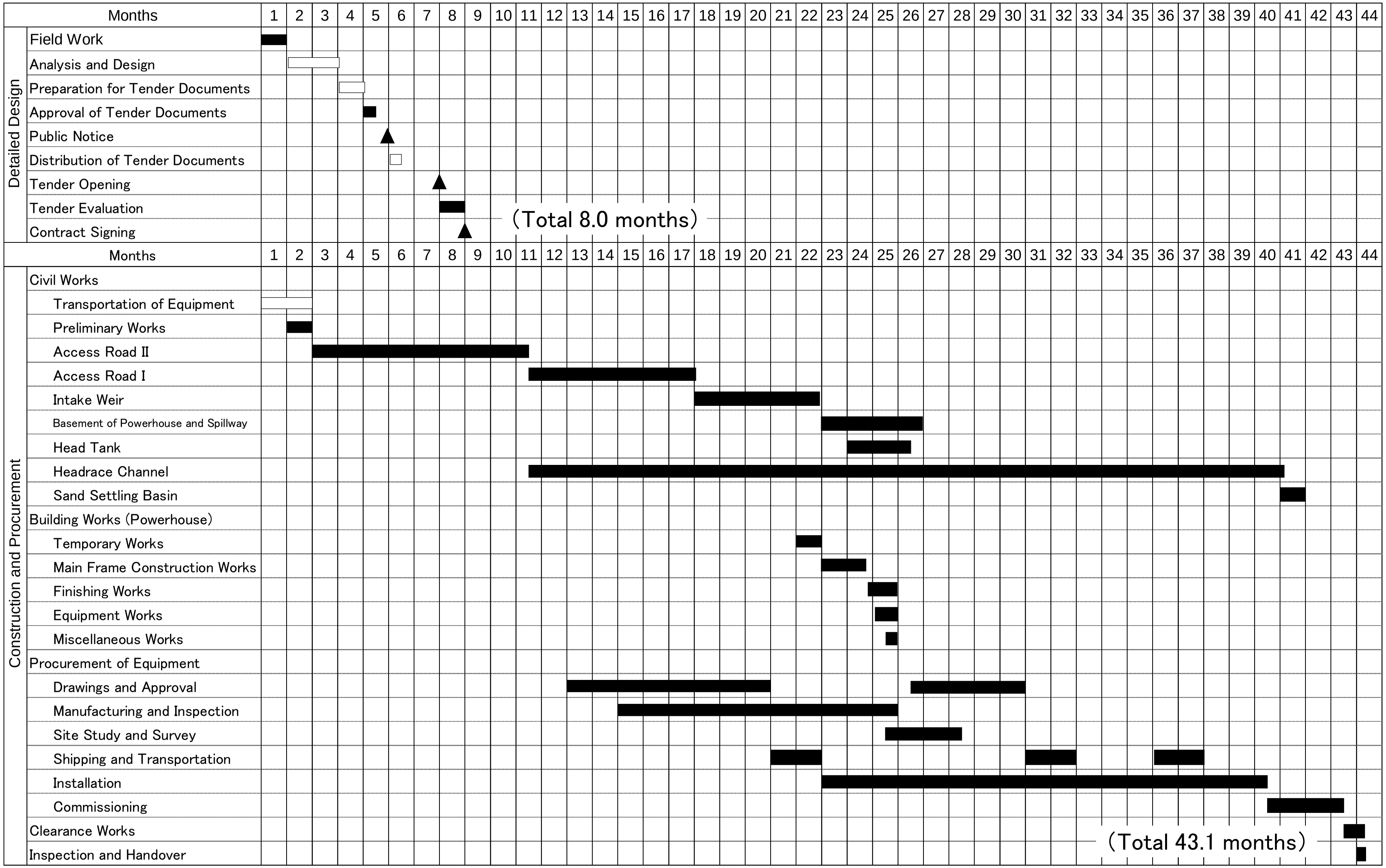
Table 2.2-20 Overall Implementation Section of soft (Draft)



2.2.4.9 Implementation Schedule

E/N will be concluded after the Japanese government approves the Project and the Project will commence based on the Japanese Grant Aid Policy. There are three (3) stages in the Project: ① detailed design, ② selection of the contractor including the preparation of tender documents, announcement of tender, evaluation of tender; and ③ construction (civil and building works) and procurement of equipment. The following table shows the project implementation schedule.

Table 2.2-21 Project Implementation Schedule



2.3 Security Plan

(1) Crime and Safety Situation

In Vanuatu, generally crime rates are low, but it has been pointed out that the public security has deteriorated in the urban areas over the years and especially, juvenile crimes have increased due to the moral degeneration of young people. Most crimes have happened in Port Vila, the capital of Vanuatu, and the urban areas in Santo Island and Malekula Island.

In and around Port Vila, burglaries and street crimes have increased due to population concentration and high unemployment rate. It is necessary to ensure that the doors and windows are locked when going out and avoid going out alone at night and late at night. There has been a burglary at a Japanese house in Luganville, Santo Island and therefore, it is very important to ensure that effective security measure such as barred windows are installed in the building.

(2) Terrorism and Abduction Threat

Though Vanuatu has been assessed as a low-threat country for terrorism, it is necessary to pay careful attention to acts of terrorism in the neighboring developed countries such as Australia. No abduction case involving Japanese nationals has been confirmed in the recent years in Vanuatu.

2.4 Obligations of Recipient Country

The scope of the works to be undertaken by the Recipient Country is as follows.

	Obligations of the recipient country	Allocation of Responsibilities
1	Acquisition and free provision of land (Generation facilities) necessary for the project.	DOE is the responsible agency and will coordinate with DOL
2	Lease right and free provision of land (Transmission line and access road) necessary for the project.	DOE is the responsible agency and will coordinate with DOL
3	Acquisition and free provision of land necessary for the temporary facilities and land clearance	DOE is the responsible agency and will coordinate with VUI
4	Provision of free disposal yard necessary for the project.	DOE is the responsible agency and will coordinate with DOL
5	Provision of free disposal sites required for the waste soil and waste materials	DOE is the responsible agency and will coordinate with DEPC and Local government
6	Provision of free storage site necessary for the equipment and materials.	DOE is the responsible agency and will coordinate with VUI
7	Maintenance and repair of existing access roads outside of the project	DOE is the responsible agency and will coordinate with Local government
8	Provision of free appropriate disposal sites necessary for the waste water and waste oil.	DOE is the responsible agency and will coordinate with DEPC and Local government
9	Bearing of commissions applied by the bank in Japan for banking services based upon the Bank Arrangement (B/A) (ex; Payment of bank commission)	DOE is the responsible agency

	Obligations of the recipient country	Allocation of Responsibilities
10	Application and acquisition of permission required for construction.	DOE is the responsible agency and will coordinate with the relevant agency
11	All expenses and prompt execution of unloading and customs clearance at the airport and the port of disembarkation in the recipient country	DOE is the responsible agency
12	Ensuring presence test of equipment and materials by experts and technical transfer to operators and maintenance staff for proper operation and maintenance	DOE is the responsible agency and will coordinate with VUI
13	Assignment of counterparts specialized for the project.	DOE is the responsible agency
14	Accommodating of Japanese nationals and/or nationals of third countries, including persons employed by the agent whose services may be required in connection with the components such facilities, as may be necessary for their entry into the recipient country and stay therein for their works	DOE is the responsible agency
15	Ensuring that customs duties, internal taxes and other fiscal levies that may be imposed in the recipient country with respect to the purchase of the components and to the employment of the agent will be exempted by the Government of recipient country	DOE is the responsible agency and will coordinate with relevant agency
16	Proper and effective operation and maintenance of the facilities and equipment that is provided under the Grant Aid Program.	VUI shall implement under control of DOE, which is the responsible agency
17	All expenses, other than those covered by the Grant Aid Program and its accrued interest, necessary for the purchase of the components as well as the agent's fees.	DOE is the responsible agency
18	Compliance to environmental and social considerations for the Grant Aid Program	DOE is the responsible agency and will coordinate with DEPC
19	Approval of EIA (Conditions of approval should be fulfilled, if any) and securing the necessary budget for implementation.	DOE is the responsible agency and will coordinate with the relevant agency

2.5 Project Operation Plan

2.5.1 Basic Policy

The new hydroelectric power plant is planned to be a remote supervisory control operated by means of an automatic control operation system from the existing Sarakata river hydroelectric power plant. Operation and monitoring of the new power plant can be done by using control, monitoring and measuring devices. Manpower for the operation and maintenance of the new power plant is equivalent to the minimum number of persons required during emergencies

At present, the adjustment of power output between the existing Sarakata river hydroelectric power plant and the Luganville diesel power plant is done manually by means of mobile phones.

Optimum operation for momentarily varying load will become more difficult in case of manual output adjustment. In order to solve this problem the remote control operation from the existing power plant by means of Optical Fiber Complex Overhead Ground Wire (OPGW), which connects the existing power plant and the new power plant, has to be introduced. Shortage in energy generated by the hydroelectric power is complemented by diesel power.

By having preventive maintenance as a part of maintenance management, it is possible to prevent the troubles makes electro-mechanical equipment during the operation, and it reduces deterioration and extends the lifetime. Therefore, it is possible to reduce the repair costs. Maintenance of each electro-mechanical equipment such as inspection, test and readjustment is scheduled by means of specific procedures decided in advance. The durable years and hours of each part has to be determined and each part should be replaced after its specified usage term. The above process is called preventive maintenance

It is necessary to carry out comprehensive maintenance management through daily patrol inspection, replacement of parts and periodical maintenance management, to evaluate the deterioration of equipment in order to prevent serious damages.

2.5.2 Operation and Maintenance Plan

(1) Organization and System of VUI

UNELCO, which conducts power supply business in three (3) concession areas, namely, Port Vila, Malekula and Tanna, had provided power supply to Luganville concession area from 1990 to 2010 based on a twenty (20) year concession contract. With the end of the contract, Vanuatu Utilities and Infrastructure Limited (VUI) which is the subsidiary company of Pernix Group, Inc. was selected as the new power supplier, through the bidding that was carried out to select the power supplier from the year 2011. Unlike UNELCO, VUI has conducted power supply business under the form of vertical integration, starting from power plant operation, distribution, up to collection of electricity bill in Luganville concession area since January 2011

However, UNELCO, which was not selected, has sued the government stating lack of transparency in government's procedures during the bidding. Therefore VUI was not selected. Due to this, a long-term concession contract has not been concluded between the government and VUI, and the power supply business is consigned by exchanging a memorandum. In order to overcome the difficult condition, the government restarted the bidding process for the concession of Luganville in December, 2016. On June 12th, 2019 the official contract between the government and VUI was signed. The organizational structure of VUI is shown in Figure 2.5-1 and the accountant division, electricity division, operation division and the customer service division are arranged under General Manager.

Source: VUI

Figure 2.5-1 Organization Chart of VUI

(2) Current status of system of operation, maintenance and management

Power output adjustment of diesel generators in the Luganville diesel power plant and the existing Sarakata river hydroelectric power plant is conducted by means of radio. In case of excess or shortage in the output of the hydroelectric power plant, the operator of the hydroelectric power plant communicates with the operator of the diesel power plant by means of radio, and the diesel generator is stopped or started as required.

Operation and maintenance system of the existing Sarakata river hydroelectric power plant consists of five (5) groups of ten (10) persons and one (1) security. Daily operation system is three (3) shifts for every eight (8) hours, and two (2) persons are present in each shift. One (1) group carries out tasks such as clearing of intake weir, opening of channel and cutting bushes, grasses etc. and another group is off.

Opening of sluice gates for clearing sediments is to be carried out once every year, so the power plant stops during the clearing sediments.

Table 2.5-1 Contents of inspection

item			Content
Inspection	Periodical inspection	External inspection	Cleaning of intake screens, cutting bushes, grasses etc.
		Internal inspection	Sand sluice gates of intake weir and the settling basin are opened and sediment clearing is done once every year. So, the operation of the power plant is stopped during the clearing of sediments.
	Extra inspection		The intake gate is closed and the operation of power plant stopped during a flood, because driftwoods, falling leaves, trash etc. block the screen. When a flood occurs, the operation of the power plant is stopped and the inspection and clearing of screen is done. An extra inspection is carried out when an earthquake occurs.
Site investigation			The Consultant carries out site investigation for matters such as shoulder sliding of access roads leading to the existing power plant, slope sliding of foundation of an open channel, erosion around the slope of the head tank and so on (December 2001)

(3) Budget of operation, maintenance and management

Costs of operation maintenance and management are used for calculating the electricity bill of VUI by URA. The electricity bill is specified as the cost to be collected from consumers fairly. These costs include operation cost, fuel cost, depreciation, taxes, operator's and maintenance staff's salary etc. for the hydroelectric power plant, diesel power plants, transmission/ distribution lines and substation facilities. Details of the cost are given in Table 2.5-2. The sum of labor and fuel costs account for about 60% of total cost. The fuel cost in 2016 of the drought year is around 50% more than one in a normal year.

Table 2.5-2 VUI expenses of operation, maintenance and management

Fiscal year / item	2013	2014	2015	2016	2017
Labor	132,626,018	105,535,948	99,161,610	99,682,941	109,992,033
Fuel & Lubricant	67,963,449	61,510,827	72,524,527	111,023,253	79,015,483
Repair & Renewal	27,039,696	16,782,971	16,653,748	16,653,748	17,111,013
Goods & Other	51,079,518	52,667,593	24,178,098	23,363,221	26,926,675
Depreciation	2,766,513	3,046,782	1,637,172	3,608,184	2,167,026
Insurance	17,237,283	18,431,304	18,740,263	18,740,263	18,740,000
New Installations	16,641,660	20,107,616	17,640,691	18,222,321	18,769,827
Bad debts	6,100,857	-2,543,426		2,493,045	1,516,165
Street Lighting	878,544	2,680,353	1,576,769	1,588,321	1,339,528
Other Operating costs			30,631,418	28,674,543	14,930,791
Fuel & Lubricant of Port Olry					9,587,296
Total	**322,333,538**	**278,219,968**	**282,744,296**	**324,049,840**	**300,095,837**

Source: VUI

(4) Organizing Results of Accidents, Problems etc.

Accident/ trouble records are extracted from VUI reports and two (2) major causes are examined below.

1) Accidents/ troubles of Transmission line

Most accidents/ troubles of transmission line occurs most frequently, but details of causes are not described. Since the duration of accidents/ troubles is short and the recovery is done by turning on the power breaker, the following four (4) causes are assumed.

- Lightening stoke
- Contact by birds
- Contact by trees fallen by a storm
- Sling due to apery

To prevent accidents caused by lightning stroke, it is desirable to install a lightning rod to protect the power system equipment, because there are no lightning rods in the existing power plant at the transmission end of 20kV transmission line and at the Luganville substation which is the receiving end. On the other hand, countermeasures for other causes are nor necessary because the system is recovered soon after an accident.

20 kV transmission line has eight (8) branches distributing electricity to the customers and there are three (3) disconnectors in the line. The insulation is removed and the insulated conductor is exposed at the branch. Disconnectors of the system is an outdoor exposed type breaker point, which is different from the one used in Japan. In order to reduce the occurrence of above accidents, the conductor at the branch shall be protected by an insulating tape and the exposed portions shall be eliminated. In addition, the existing disconnectors shall be replaced to outdoor enclosed type disconnector (directional/non-directional, built-in VT・built-in LA/ Pole Air Switch)

Following are the benefits of adopting an outdoor enclosed type disconnector (PAS).

a) Separate the accident point and minimize the area of blackout.

b) Able to prevent the blackout of other lines simultaneously, by ground fault of the consumer of other lines.

c) Be a back-up for the existing fragile protection system by the adoption of directional, built-in VT and built-in LA PAS.

d) Able to prevent the ground fault and short circuit accidents due to contacts of external obstacles by applying covered cable to transmission line and eliminating exposed portions.

2) Cyclones

Flying objects such as branches, timbers touch the lines frequently during Cyclones, which is a major cause of accident. Since the duration of accidents is longer, the accident is assumed to be breakage of cable and damage to electric poles, and it is assumed that the repair work is carried out after the passage of the Cyclone.

In order reduce the occurrence of accidents caused by Cyclones on the new transmission line, the exposed portions at the branch shall be covered by an insulating tape and the outdoor enclosed type disconnector (PAS) shall be adopted. The same shall be adopted in the existing transmission line. In addition, speedy repair will be done, after the passage of the Cyclone.

2.5.3 Control Items of Maintenance Activities

Overview of daily and periodic inspections as stated in the basic policy is provided below.

(1) Daily Patrol Inspection

The daily patrol inspection is carried out every day in order to detect whether there is any abnormality and/or a sign of abnormality in the generating facilities, i.e., electro-mechanical equipment.

Daily patrol inspection is simple method to detect abnormal noise, vibration, overheating, and water and oil leakage, etc. in an electro-mechanical equipment by performing visual observation, hearing and smelling. The daily patrol inspection is normally carried out in one (1) time/day by using the daily patrol inspection sheet. Detailed inspection is performed by maintenance group if an abnormality is observed.

(2) Periodic Inspection and Deterioration Diagnosis

The periodic inspection is an inspection to be performed within a specified period to observe damage, corrosion and abrasion of electro-mechanical equipment and facilities, in order to prepare maintenance plan for repairs, replacement etc.

The periodic inspection and deterioration diagnosis are proposed to be carried out every three (3) years basically.

Table 2.5-3 Periodic Inspection and Deterioration Diagnosis

Facility	Daily Patrol Inspection		Periodic Inspection and Deterioration Diagnosis		
Electro-mechanical equipment and civil facilities	Facility	Frequency	Facility	Item	Frequency
	Electro-mechanical equipment and civil facilities	one time/day	Electro-mechanical equipment	Periodic Inspection	one time/ three (3) years
				Deterioration Diagnosis	
				Detailed Inspection	At abnormal condition
Transmission line		one time/ week			

(3) Overhauls of turbine and valve

Target of the overhaul frequency of the turbine and valves is shown in Table 2.5-4. The degree of cavitation and abrasion due to hard sediments in the turbine and valves can be observed by an overhaul, which is carried out after one (1) year operation. On the basis of this result, the specific frequency and detailed inspection items of the overhaul are determined.

Table 2.5-4 Overhaul of Turbine and Valves

Item	Frequency
Overhaul after Operation	One (1) year after operation
Overhaul	one time/ten (10) years

(4) Procurement plan of Spare parts

Not only electro-mechanical equipment but also spare parts shall be procured. Parts shall be replaced periodically (every 5 to 10 years), and parts shall be prepared to continue the operation without troubles.

Periodical replacement interval of 5 (five) to 10 (ten) years is required for the packing of turbines and valves. Also, whenever spare parts are used to solve troubles of electro-mechanical equipment etc., the spare parts shall be purchased and supplemented. As the business owner VUI is responsible for this supplement.

Failure frequency of electro-mechanical equipment varies according to the frequency of use, condition of installation place, lightening failure frequency of power system etc. If procurement of parts is done once troubles of electro-mechanical equipment occur, it will take time to place an order to the manufacturer who produces damaged parts (medium and small size companies in Japan) and acquire the damaged parts. Time in incurred in ordering procedure, manufacturing parts, delivering etc. and the operator is forced to stop operation of power plants for a considerable time. Therefore, it is necessary to procure and keep such parts that are prone to failure for a duration of 10 (ten) year from the commission, when an overhaul is scheduled.

Based on the above, the following spare parts are determined to be required for the Project.

Table 2.5-5 List of Spare Parts

equipment	Spare part	Quantity	Remarks
1. Turbine	Bearings	1 set	
	Shaft water seal packing	1 set	
	Packing	1 set	
2. Generator	Bearings	1 set	
3. Control and Switchgear boards	Protection relay	1 set	
	Auxiliary relay	1 set	

2.5.4 Medium- and Long-term Monitoring and Maintenance Plan

The life time of a major electro-mechanical equipment of hydroelectric power system such as the turbine and generator is assumed to be longer than twenty (20) years, and the life time of the battery is assumed to be around ten (10) years. Especially, the life time of the turbine is greatly affected by the cavitation and abrasion due to hard sediments.

Actual life time of electro-mechanical equipment depends on the implementation status of periodic inspections, frequency of replacement of parts, day-to-day maintenance state. If proper maintenance is not carried out, it is necessary to replace not only the defective parts but also the new equipment. As a result, a great expense is incurred. Therefore, appropriate daily patrol inspection and periodic inspection, as well as, the evaluation of the deterioration diagnosis are important. In addition, continuously recording maintenance information such as inspection results, history of failure, contents of repair of facility equipment, hours of operation, and their analysis is essential to help in the development of a more effective maintenance plan.

2.6 Project Cost Estimation

2.6.1 Initial Cost Estimation

2.6.1.1 Obligation of Vanuatu Side

The following cost shall be the burden of the Vanuatu side.

The cost borne by Vanuatu side: VUV 71,476,000

Table 2.6-1 Cost borne by the Vanuatu side

Contents	Price in VUV
Site acquisition/ Compensation for land users and owners/ land rent for disposal area if necessary	60,375,000
Repairs and maintenance expenses for existing access roads	2,247,000
Preparation and provision of lands for stockyard and parking place	105,000
Preparation and provision of lands for site offices	105,000
Commission related to Banking Arrangement (B/A) and Authorization to Pay (A/P)	3,786,000
Customs clearance of the products at ports of disembarkation in Vanuatu	3,500,000
Approval of EIA (Conditions of approval should be fulfilled, if any) and securement of the necessary budget for implementation	100,000
Obtaining the planning, zoning, building, and water works permit	50,000
Preparation and provision of lands for temporary disposal area for surplus soil	1,208,000
Total	71,476,000

Source: JICA Study Team

2.6.1.2 Condition of Quotation

(1) Time of Estimation

The Project cost was estimated in March of 2019.

(2) Exchange Rate

The Project cost was estimated using the following exchange rate.

1 USD = JPY 111.62
1 VUV = JPY 1.01

(3) Construction Period

Construction period is 43.1 months as shown in the project schedule.

2.6.2 Operation and Maintenance Cost

The existing Sarakata River Hydropower Plant of 1,200 kW with 2-unit 300kW (1st phase) from 1994 to 1995 and 1-unit 600kW (2nd phase) in 2009 was installed with the Japanese grant aid. Initially UNELCO operated and maintained the power plant, then VUI have taken over since 2011 under the concession agreement. The operation and maintenance of the new hydropower station will be conducted by VUI. The operation and maintenance personnel of the existing Sarakata River hydropower station have been engaged since the first phase of operation and have a wealth of experience. They will be able to concurrently serve for both existing and new hydropower station by installing a remote control operation system at the new hydropower station.

In order for VUI to continuously and soundly operate the electric power business, it is necessary to appropriately maintain and manage the equipment procured under this project. Therefore, in addition to the operation and maintenance costs for power plant, it is necessary to formulate an operation and maintenance plan that allows for the regular equipment renewal costs shown in Section 4.3.

The equipment procured under this project will be put into service in 2025. The annual expenditure is estimated on the assumption that the renewal cost of major parts (about 200 million yen/unit), which will be required about ten (10) years later, will be accumulated as a reserve fund. The purchase cost of spare parts for hydropower plants for No. 1 and No.2 units was set at five (5) million VUV/unit.

The source of the reserve fund is electricity bill revenue and the reduction of fuel cost for diesel power generation. Operation and maintenance cost are assumed as the following conditions.

- Fluctuation of the fuel cost for diesel power generation was large from 2011 to 2018 and unit cost is 128.1VUV/liter maximum, 72.9 VUV/liter minimum, and 105.6 VUV/liter average. After 2016 the cost was decreased up to the 70s VUV/liter suddenly. It is assumed to be 106 VUV/liter from 2019.

- Fuel consumption for diesel power plant per kWh is 0.29 liter/kWh. Lubricant cost is assumed to be 10% of fuel cost.

- Annual increasing rate of cost of spare parts for diesel power plants is assumed to be 2%.

- Green Energy Fund of 2 VUV/kWh is collected from February, 2020 instead of Santo fund and Government fund.

- Maintenance cost of turbine and generator is assumed to be 10,000 VUV/year/kW.

- 40 million VUV/year is reserved every year for replacement of major equipment after commercial operation year.

- Reduction of the electricity tariff is expected to be 10 VUV/kWh from the benefits of a new hydropower plant.

- Budgetary shortage during the period from January 2011 to June 2019 was compensated by Operation and Maintenance Agreement based on the Contract of Concession. (about 87 million VUV) It is assumed that Santo fund and Government fund are compensated by that amount. From 2020 to 2024 NGEF is assumed to be compensated by the O & M Agreement which will be concluded newly.

The assumption of operation and maintenance cost is shown in Table 2.6-2.

Table 2.6-2 Assumption of operation and maintenance costs

Year	unit	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
											completion 2025/6			evaluation after 3 yrs		
Annual generated energy	MWh	10,122	10,482	10,346	10,728	11,123	11,534	11,959	12,400	12,857	13,332	13,823	14,333	14,862	15,410	15,979
Diesel power	MWh	5,008	3,299	3,512	3,883	4,269	4,669	5,084	5,516	5,963	3,453	961	717	1,236	1,774	2,333
Solar power	MWh	60	48	58	68	78	88	98	108	118	128	138	148	158	168	178
Hydro power	MWh	5,054	7,135	6,776	6,776	6,776	6,776	6,776	6,776	6,776	9,750	12,724	13,468	13,468	13,468	13,468
Electric power sales																
Electricity bill	VT/kWh	43.25	36.64	38.52	38.52	40.00	41.00	42.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
Electricity bill after completion of new plant	VT/kWh										33.00	33.00	33.00	33.00	33.00	33.00
Electric power sales	MWh	8,983	8,980	9,311	9,655	10,011	10,380	10,763	11,160	11,572	11,999	12,441	12,900	13,376	13,869	14,381
Income of electric power sales	1000VT	388,517	329,055	358,674	371,904	400,437	425,588	452,048	479,882	497,583	515,936	534,966	554,698	575,158	596,372	618,369
Generation cost																
Diesel power																
Unit price of fuel	VT/liter	72.9	77.0	80.0	85.0	90.0	95.0	100.0	106.0	106.0	106.0	106.0	106.0	106.0	106.0	106.0
Fuel cost	1000VT	111,023	79,015	81,821	96,135	111,900	129,193	148,092	170,287	184,099	106,613	29,668	22,146	38,160	54,775	72,015
Cost of grease etc.	1000VT	11,102	7,902	8,182	9,614	11,190	12,919	14,809	17,029	18,410	10,661	2,967	2,215	3,816	5,478	7,202
Cost of spare parts	1000VT	24,464	25,220	29,836	30,673	31,526	32,397	33,284	34,190	35,114	36,056	37,017	37,998	38,998	40,018	41,058
Hydro power																
Cost of grease etc.	1000VT															
Spare parts	1000VT	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	22,000	22,000	22,000	22,000	22,000	22,000
Operation management cost	1000VT	176,562	174,273	197,459	201,408	205,436	209,545	213,735	218,010	222,370	226,818	231,354	235,981	240,701	245,515	250,425
sub-total	1000VT	335,152	298,410	329,298	349,829	372,052	396,053	421,921	451,516	471,993	402,149	323,006	320,340	343,674	367,785	392,700
sub-total (excluding fuel, grease etc.)	1000VT	213,027	211,493	239,294	244,080	248,962	253,941	259,020	264,200	269,484	284,874	290,372	295,979	301,699	307,532	313,483
Funds																
Santo fund (1 VT/kWh)	1000VT	8,983	(8,980)	(9,311)	(9,655)											
Government fund (2 VT/kWh)	1000VT	17,966	(17,960)	(18,623)	(19,310)											
Green Energy fund (2 VT/kWh)	1000VT					(20,022)	(20,760)	(21,526)	(22,320)	(23,143)	23,997	24,882	25,800	26,752	27,738	28,761
Balance (1)	1000VT	**26,415**	**30,645**	**29,376**	**22,075**	**28,385**	**29,535**	**30,128**	**28,366**	**25,589**	**89,790**	**187,078**	**208,558**	**204,732**	**200,849**	**196,908**
5VUV/kwh discount of electric bill	1000VT										59,993	124,411	129,000	133,758	138,691	143,807
reserve of replacemet of turbine/ generaor	1000VT											40,000	40,000	40,000	40,000	40,000
Balance (2)	1000VT										**29,797**	**22,667**	**39,559**	**30,975**	**22,158**	**13,101**

3. Project Evaluation

3.1 Preconditions

(1) Land Acquisition and Easement

The Project area is a private land called "Customary Land", which is a part of the land where a private enterprise rent the land and conducts plantation business. For this reason, DOE started negotiations and procedures for land acquisition. The land acquisition cost is planned to be covered by the 2021 budget and will be acquired after the conclusion of the E/N.

The land for the power station including the area around the power generation facility and part of the access roads will be acquired, and the easement of the access roads and transmission line route will be obtained. The disposal area will be temporarily placed in the plantation and land acquisition will not be performed.

(2) Environmental Approval

DOE will obtain an Environmental Impact Assessment (EIA) approval from DEPC (Department of Environmental Protection and Conservation). It was confirmed that there was no living area for residents in the Project area, and no resettlement of residents occurred.

(3) Tax Exemption Procedure

DOE, as a responsible agency, will perform tax exemption procedure of customs duties and value added tax (VAT) for this Project. Major equipment transported by sea freight from Japan will be landed at Luganville Port and will be transported by land to the site. Therefore, DOE needs to know in advance the tax exemption procedure for customs clearance.

(4) Permission for Construction

For the construction works in the river (construction of the weir), "Water work permit" should be required from DOWR (Department of Water Resources, Ministry of Land and Natural Resources) before construction starts. If the crushed stone form the river is to be used as construction material, "Quarry Permit" should be obtained from DOWR as well.

(5) Power Generating Operation License, etc.

Before the commercial operation of the facility, it is necessary to obtain "Water Use License" from DOWR.

(6) Forecast of Balance of Power Supply and Demand

Forecast of balance of power supply and demand was carried out up to 2030 based on power demand forecast in case that 1,000kW-scale new hydropower plant is operated in June, 2025 under the following conditions.

- Annual increase rate of peak power demand is 3.3% and one of sales electric energy is 3.7%.
- Sales electric energy are calculated 10% less than available generated energy due to transmission loss, collection rate of electricity bill etc. considering a rate of actual generated energy and sales electric energy.

- Annual decrease rate of power output of diesel power plants is assumed to be 1%.
- Annual increase of generated energy of solar power is assumed to be 10 MW/year.
- Annual available generated energy of the existing Sarakata River hydropower plant is 6,776MWh/year based on average of actual generated energy from 2011 to 2017.
- Annual generated energy of a new hydropower plant are 7,435MWh/year (available generated energy 8,992MWh/year X (10/12)) considering two (2) month stoppage per year due to periodical maintenance and accidents etc. Sales electric energy is assumed to be 6,692MWh/year, which is 10% reduction of the generated energy.
- Commercial operation will start from June 2025. After three (3) years from the commercial operation all generated energy becomes sales electric energy.
- For deficiency of energy generated from hydropower and solar power, diesel power plants are to be operated. Diesel volume required for generation per kWh is 0.29 liter/kWh.

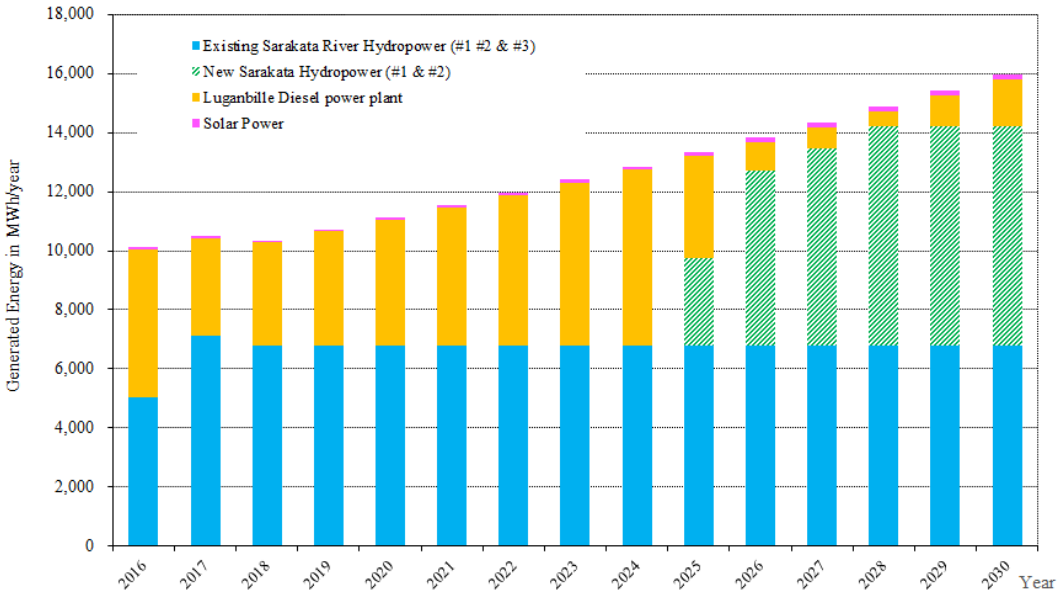


Figure 3.1-1 Annual Generted Energy of Various Power Sources (2016-2030)

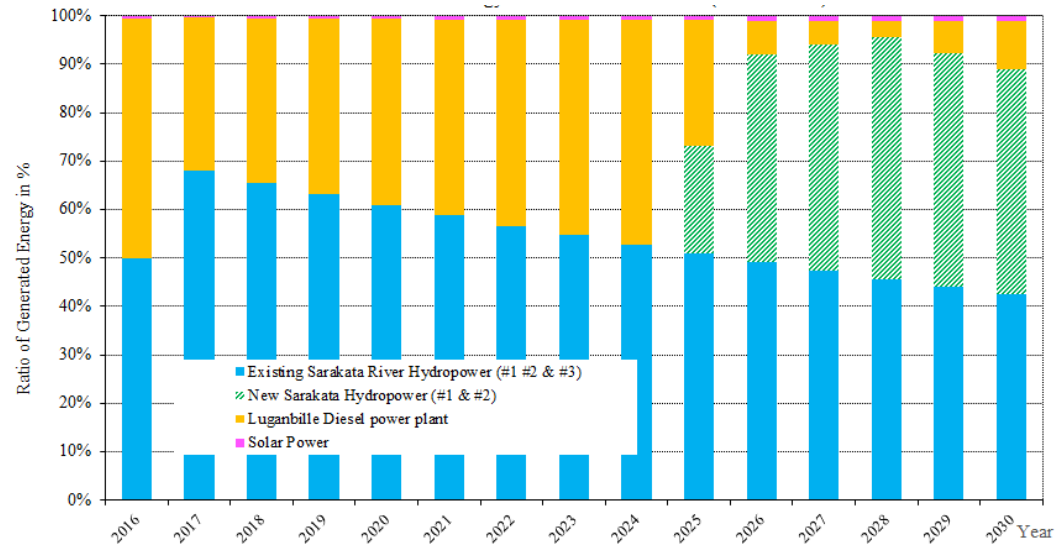


Figure 3.1-2 Annual Generted Energy Rates of Various Power Sources (2016-2030)

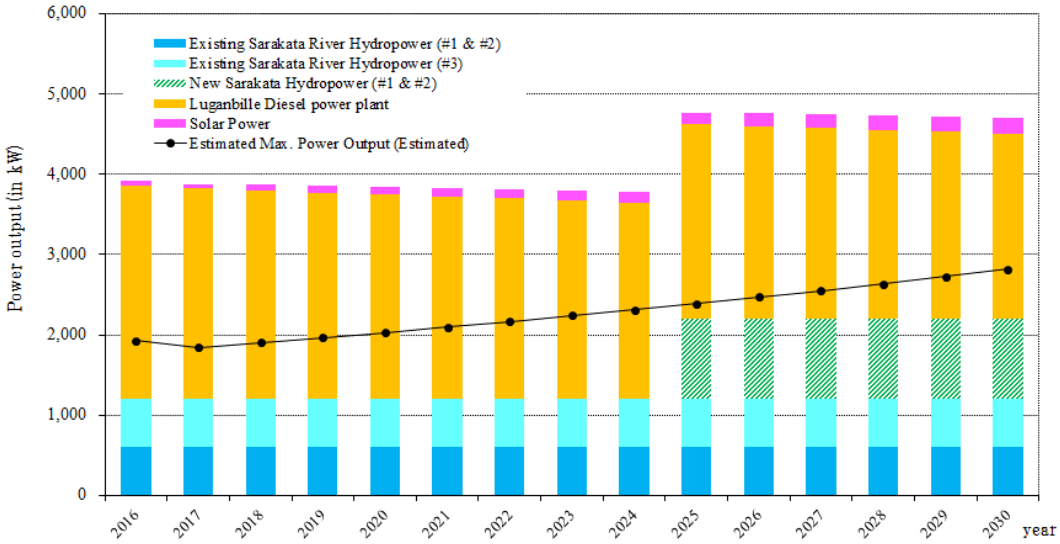


Figure 3.1-3 Power Output of Various Power Sources (2016-2030)

3.2 Necessary Inputs by Recipient Country

Proper operation and maintenance of the hydropower plant is essential in order to realize and sustain the effects of the Project. It is important to secure a budget and to implement a maintenance plan that incorporates preventive maintenance, as well as daily maintenance inspection.

It is important to properly utilize the effect of reducing the fuel cost of reducing the diesel power generation by introducing a new hydropower station to reduce electricity tariff and to fund for National Green Energy Fund.

3.3 Important Assumptions

The external conditions for realizing and sustaining the effects of this project are shown below.

- The power generation and transmission line facilities will not be damaged by large-scale natural disasters (earthquakes, cyclones, etc.) or political confusion.
- River discharge will not be affected with drastically decrease by climate change.
- Accidents or breakdowns of VUI's distribution facilities and substation equipment in the power plants that are connected to the grid will not cause large-scale distribution interruptions.
- Electricity tariff is to be properly maintained without increasing in the necessary expenditure for maintenance cost of the power plant.

3.4 Project Evaluation

3.4.1 Relevance

The relevance of the Project is judged to be high as described below.

(1) Increase the renewable energy ratio in Vanuatu

This Project will contribute to improve the renewable energy ratio based on the energy roadmap of Vanuatu.

The total installed capacity of the existing Sarakata River Hydropower Station of 1,200 kW and the installed capacity of the new hydropower station of 1,000 kW will be 2,200 kW. The peak demand will be 2,392 kW at the commencement of commercial operation in 2025 according to the demand forecast of an increase rate of 3.3 % per year from the current demand of 1,900 kW in 2018. The renewable energy ratio for the peak demand will be about 83% in 2028 three (3) years after completion of this Project, increasing from 52% in 2025. One for generated energy sales of an increase rate of 3.7 % per year will be about 92% in 2028, increasing from 54% in 2025. This means that the existing and new hydropower stations constructed by Japan's grant aid project will supply most of the electricity demand as the main power source. However the hydropower output is to be decreased in the dry season as the river discharge decreases because of run-of-river type.

(2) Reduce dependence on imported fuels and reduce electricity tariff

The existing and new hydropower plants will cover most of the peak demand and base load power demand, which will contribute to save diesel fuel. The saved fuel cost can be secured as a financial source for reducing electricity tariff.

(3) Contribute to climate change countermeasures by reducing dependence on imported fuel

Reducing diesel power generation will reduce fuel for diesel power generation, which will also lead to a reduction of greenhouse gas emissions.

(4) Contribute to rural electrification projects

The Vanuatu government established a two (2) VUV/kWh National Green Energy Fund (NGEF) in 2019, abolishing the current one (1) VUV/kWh Santo Fund and two (2) VUV/kWh government fund. The purposes of this fund are; i) to supply affordable electricity by renewable energy to off-grid households, ii) to promote and support promotion of domestic renewable energy, and iii) to enable appropriate progress in energy efficiency to be achieved by 2030.

The effect of reducing the imported fuel by this project can be utilized as a source for the National Green Energy Fund to support rural electrification projects.

(5) Consistent with the hybrid island concept

The "Hybrid Island Concept" advocated by Japan is a concept aimed at efficient and stable energy supply based on improving the efficiency of diesel power plants to reduce fuel consumption (maintaining materials and equipment, improving maintenance capacity), and mainstreaming renewable energy.

This project will be implemented as a part of supporting the achievement of low-carbon development through continuous implementation, in line with this "Hybrid Island Concept".

As shown in discussions above, it is considered to be appropriate as a grant aid for the construction of Hydroelectric Power Project in Espiritu Santo Island (hereinafter referred as "this Project") since introduction of renewable energy will reduce the dependence of imported fuel, reduce the electricity tariff, and contribute to climate change countermeasures, which is based on the policy of Vanuatu.

3.4.2 Effectiveness

(1) Quantitative Effect

The quantitative effects expected from this Project are reduction of imported fuel costs by reducing fuel for diesel power generation, increasing of renewable energy ratio, and mitigation of climate change by reducing greenhouse gasses.

The target year is 2028, three (3) years after the commencement of commercial operation.

1) Electric power sales by new hydropower station

The available generated energy of a new run-of-river hydropower with an output of 1,000 kW in this Project was calculated based on the flow duration curve produced by the river discharge data obtained from the operation records from 2015 to 2018.

The annual sales generated energy will be 6,692 MWh/year, assuming power transmission loss, loss of uncollected electricity charges, etc. of 10 %, and stop power generation for two (2) months of a year by periodic inspection, transmission line accidents, etc.

On the other hands, the annual sales generated energy of the existing Sarakata river hydropower plant is to be 6,097 MWh/year, which was calculated based on actual annual average generated energy of 6,776 MWh/year from 2011 to 2017 assuming total loss of 10%

2) Reduction in fuel cost for diesel power generation

Fuel consumption for diesel power generation in 2017 is 976 kiloliter/year with purchase cost of 75 million VUV, and it will increase to 1,737 kiloliter with 184 million VUV by 2024 before the commencement of commercial operation of a new hydropower plant. 1,940 kiloliter with 205.6 million VUV will reduce in 2028, three (3) years after the commencement of commercial operation, which is equivalent to the annual sales electric energy of a new power plant (6,692 MWh/year).

3) Renewable energy ratio

The ratio of hydropower generated energy in 2017 was 68 %, and it will be decreased to about 54 % in 2024 before commencement of commercial operation of a new hydropower station. It will be increased to around 91% in 2028, three (3) years after the commencement of commercial operation. The renewable energy ratio including PV will be about 92 % in 2028.

However, since the power demand will increase after that the ratio of renewable energy will decrease. It is possible to increase the ratio of renewable energy effectively to storage surplus hydropower energy in batteries at night time when the power demand decreases and use butteries during peak daytime. For the peak daytime in the dry season when hydropower energy decreases interconnected solar power plant is effective. (refer to 1.4 Preparation for the Global Climate Fund (GCF).

4) Reduction of greenhouse gasses

Reduction of greenhouse gasses will be 602,280 tCO_2/year by increase of energy production with hydropower generation (6,692MWh/year).

JICA Climate-FIT Version 2.0, March 2014
Japan International Cooperation Agency
(Prepared by Japan Weather Association)

15. Renewable Energy / Hydropower and Others

Project Name

Santo Island Renewable Energy Promotion

Country

Vanuatu

Emission Reduction

		Value	Unit
ER_y	Emission reduction	-602,280	tCO_2/year
BE_y	Baseline emission	0	tCO_2/year
PE_y	Project emission	602,280	tCO_2/year

Inputs

1) Electricity generation projects (Grid connected system or standalone or mini-grid system)

Parameter	Description		Value	Unit
-	The project is a development of geothermal power plant		No	
-	The project is a development of hydro power plant and CH_4 emission from reservoirs of hydro power plants is significant		Yes	
EG_y	Power generation by the renewable energy system in year y		6,692	MWh/year
EF_{elec}	CO_2 emission factor of the electricity		0	tCO_2/MWh
EF_{Res}	Default emission factor for emissions from reservoirs of hydro power plants		90	$kgCO_{2-eq}$/MWh
$w_{Main,CO2}$	Average mass fraction of carbon dioxide in the produced steam			tCO_2/t
$w_{Main,CH4}$	Average mass fraction of methane in the produced steam			tCH_4/t
GWP_{CH4}	Global warming potential of methane		0	tCO_2/tCH_4
$M_{S,y}$	Quantity of steam produced in year y			t/year
$FC_{i,y}$	Consumption of fossil fuel i at the power plant in year y			t/year
NCV_i	Net calorific value of the fossil fuel i			TJ/t
$EF_{fuel,i}$	CO_2 emission factor of the fossil fuel i			tCO_2/TJ

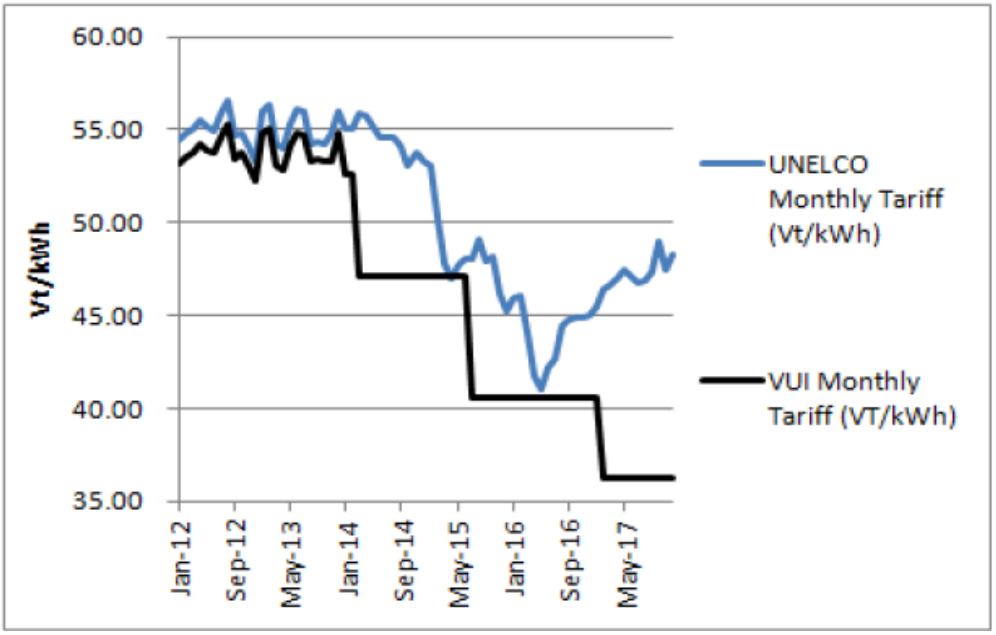
Figure 3.4-1 Input/Output of Climate Finance Impact Tool

5) Electricity tariff reduction and source of green energy fund

Electricity tariff has been revised 4 times after VUI takeover the electricity concession in 2011. The tariff in January 2018 is 38.52 VUV/kWh. However, in consideration of deteriorating of income and expenditure balance by increasing of fuel cost for diesel power generation with decreasing of the ratio of hydropower generation, the tariff is thought to be revised before commencement of a new hydropower plant. 10VUV/kWh reduction source is assumed to be secure at the year of commencement of commercial operation in 2025.

2 VUV/kWh is added to the electricity tariff as a Green Energy Fund since February 2020. This fund is used to promote rural electrification and renewable energy.

Revision	Period	Electricity Tariff	Change
VUI starts operation	After 2011 ~	54.76 VUV/kWh	
1st revision	After March 2014	47.07 VUV/kWh	-14.1%
2nd revision	After June 2016	40.52 VUV/kWh	-13.9%
3rd revision	After February 2017	36.29 VUV/kWh	-10.4%
4th revision	After January 2018	38.52 VUV/kWh	+10.8%



Source: UNELCO monthly tariff submission and Luganville census

Figure 3.4-2 Historical Fluctuation of Electricity Bill of UNELCO and VUI

Based on the conditions as discussed above, the target values of the quantitative effects as of 2028, 3 years after commercial operation of this power plant in 2017 are summarized in the table below.

Table 3.4-1 Quantitative Effects

Index name	Standard value (2017)	Target Value (2028) [3 years after the commercial operation of the Project]
Sales Electric Energy (MWh/year)	0	6,692 MWh /year
Reduction of greenhouse gasses (ton/year)	0	602,280 ton/year
Fuel reduction amount for diesel power generation	0	1,940 kliter/year

(2) Qualitative effect

The qualitative effects are as follows;

- Promoting the use of renewable energy, which contributes to improved economic/social development and reduction of greenhouse gas emissions
- Diversification of electric power supply sources
- Achievement of a stable energy supply
- Expansion of power supply area and improvement of public services
- Improvement of public security and promotion of community activities because of increasing street lights

Table 3.4-2 Actual Record and Forecast of Power Supply and Demand Balance

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	unit										completion 2025/6			evaluation after 3 yrs		
Estimated Max. Power Output (Actual)	kW	1932	1842													
Estimated Max. Power Output (Estimated)	kW			1,903	1,966	2,032	2,099	2,169	2,241	2,315	2,392	2,471	2,553	2,638	2,726	2,816
Annual increase rate	%	4.4%	-4.7%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%	3.3%
Installed capacity	kW	3,921	3,881	3,867	3,852	3,838	3,824	3,810	3,796	3,783	4,770	4,757	4,745	4,732	4,720	4,708
Luganbille Diesel power plant	kW	2,652	2,626	2,600	2,574	2,548	2,523	2,498	2,473	2,448	2,423	2,399	2,375	2,351	2,328	2,305
#1: 1000kW	kW	816	808	800	792	784	776	768	761	753	746	738	731	724	716	709
#2: 1000kW	kW	714	707	700	693	686	679	672	666	659	652	646	639	633	627	620
#3: 750kW	kW	612	606	600	594	588	582	576	571	565	559	554	548	543	537	532
#4: 500kW	kW	510	505	500	495	490	485	480	475	471	466	461	457	452	448	443
#5: 500kW	kW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#6: 500kW	kW						500	495	490	485	480	475	471	466	461	457
Existing Sarakata River Hydropower (#1 & #2)	kW	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Existing Sarakata River Hydropower (#3)	kW	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600
Solar Power	kW	69	55	67	78	90	101	112	124	135	147	158	169	181	192	204
New Sarakata Hydropower (#1 & #2)	kW										1,000	1,000	1,000	1,000	1,000	1,000
Power demand and supply balance	kW	1,989	2,039	1,964	1,886	1,806	1,725	1,641	1,556	1,468	2,378	2,286	2,191	2,094	1,995	1,892
Power demand and supply balance by Hydto	kW	-732	-642	-703	-766	-832	-899	-969	-1,041	-1,115	-192	-271	-353	-438	-526	-616
Ratio of Hydro to total	%	62.1%	65.1%	63.1%	61.0%	59.1%	57.2%	55.3%	53.6%	51.8%	92.0%	89.0%	86.2%	83.4%	80.7%	78.1%

Table 3.4-3 Actual Record and Forecast of Generated Energy and Generated Energy Sales

		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	unit										completion 2025/6			evaluation after 3 yrs		
Annual generated energy (Actual)	MWh	10,122	10,482													
Annual generated energy (Estimated)	MWh			10,346	10,728	11,123	11,534	11,959	12,400	12,857	13,332	13,823	14,333	14,862	15,410	15,979
Luganbille Diesel power plant	MWh	5,008	3,299	3,512	3,883	4,269	4,669	5,084	5,516	5,963	3,453	961	717	1,236	1,774	2,333
Existing Sarakata River Hydropower (#1 #2 #3)	MWh	5,054	7,135	6,776	6,776	6,776	6,776	6,776	6,776	6,776	6,776	6,776	6,776	6,776	6,776	6,776
Solar power plant	MWh	60	48	58	68	78	88	98	108	118	128	138	148	158	168	178
New Sarakata Hydripower (#1&#2)	MWh	0	0	0	0	0	0	0	0	0	2,974	5,948	6,692	6,692	6,692	6,692
Annual sales energy (Actual)	MWh	8,983	8,980													
Annual sales energy (Estimated)	MWh			9,311	9,655	10,011	10,380	10,763	11,160	11,572	11,999	12,441	12,900	13,376	13,869	14,381
Annual increase rate	%	9.6%	0.0%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%
Annual fuel consumption (Luganbille PP)	1000liter	1,427	976	1,023	1,131	1,243	1,360	1,481	1,606	1,737	1,006	280	209	360	517	679
Annual fuel purchase cost (Luganbille PP)	1000VT	104,023	75,015	81,821	96,135	111,900	129,193	148,092	170,287	184,099	106,613	29,668	22,146	38,160	54,775	72,015
Fuel amount per kWh	l/kWh	0.28	0.30	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Fuel unit cost	VT/liter	72.94	77.04	80	85	90	95	100	106	106	106	106	106	106	106	106
Hydro ratio (to total generated energy)	%	49.9%	68.1%	65.5%	63.2%	60.9%	58.8%	56.7%	54.6%	52.7%	73.1%	92.0%	94.0%	90.6%	87.4%	84.3%
Luganbille Diesel power plant	%	49.5%	31.5%	33.9%	36.2%	38.4%	40.5%	42.5%	44.5%	46.4%	25.9%	7.0%	5.0%	8.3%	11.5%	14.6%
Existing Sarakata River Hydropower (#1 & #2)	%	49.9%	68.1%	65.5%	63.2%	60.9%	58.8%	56.7%	54.6%	52.7%	50.8%	49.0%	47.3%	45.6%	44.0%	42.4%
Solar Power	%	0.6%	0.5%	0.6%	0.6%	0.7%	0.8%	0.8%	0.9%	0.9%	1.0%	1.0%	1.0%	1.1%	1.1%	1.1%
Existing Sarakata River Hydropower (#3)	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.3%	43.0%	46.7%	45.0%	43.4%	41.9%
Total of Hydro	%	49.9%	68.1%	65.5%	63.2%	60.9%	58.8%	56.7%	54.6%	52.7%	73.1%	92.0%	94.0%	90.6%	87.4%	84.3%
Total of Renewable energy	%	50.5%	68.5%	66.1%	63.8%	61.6%	59.5%	57.5%	55.5%	53.6%	74.1%	93.0%	95.0%	91.7%	88.5%	85.4%