SOUTH PULANGI HYDROELECTRIC POWER PLANT PROJECT

Municipalities of Damulog, Dangcagan, Kibawe, and Kitaotao
Province of Bukidnon

ENVIRONMENTAL IMPACT STATEMENT

Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas Jr. Road, Ortigas Center Pasig City

PHPC
Pulangi Hydro Power Corporation
15th Floor, Ramon Magsaysay Center
1680 Roxas Boulevard cor. Quintos St.
Malate, Manila

JULY 2019

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A. BASIC PROJECT INFORMATION

Name of Project:	**SOUTH PULANGI HYDROELECTRIC POWER PLANT PROJECT**
Project Location:	Municipalities of Dangcagan, Damulog, Kibawe, and Kitaotao, Province of Bukidnon
Project Proponent:	**PULANGI HYDRO POWER CORPORATION (PHPC)**
Proponent's Address	15th Floor Ramon Magsaysay Center, 1680 Roxas Blvd., cor. Quintos St., Malate Manila
Contact Person:	**MR. JOSUE A. LAPITAN**
Position/ Designation:	President and Chief Executive Officer
Contact No:	Tel Nos.: (02) 554-9963/ (02) 567-1654 Email add: phpchydro@gmail.com
Name of Consultant:	**LICHEL TECHNOLOGIES INC.**
Consultant's Address:	Unit 1403 Prestige Tower Condominium, F. Ortigas Jr. Road, Ortigas Center, Pasig City
Contact Person:	**RACHEL A. VASQUEZ**
Position/ Designation:	Managing Director
Contact No:	02-633-00-94
E-mail Address	ravasquez@licheltechnologies.com
Estimated Project Cost	US $ 699,666,000.00 or Php 37,369,161,060.00 (as of Aug 14, 2018 exchange rate of Php 53.41)

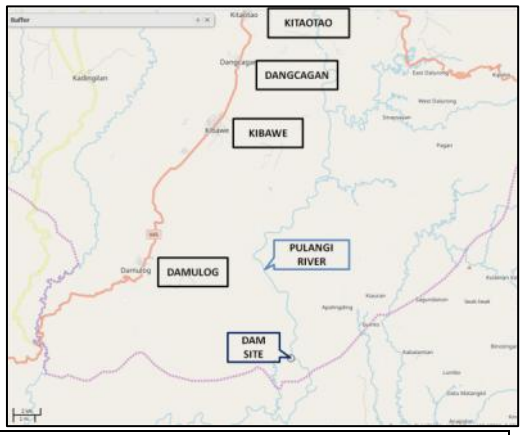


Table ES 1: Summary of Projec Component

	Project Component	Description/Specification
1	Dam	
	Dam type	Concrete face rockfill dam
	Maximum dam height	143.1 m
	Length of dam crest (including spillway)	878.5 m
2	Reservoir	
	Area	2,924 ha
	Storage capacity	1169.3 10^6 m^3
3	River Diverison and Outlet Facilities	
	Cofferdam Elevation	73 m
	Design Flood	1.5 year return period
	Diversion Tunnel-diameter	10 m
	Number of untis	3
	Length	900 m
4	Spillway	
	Elevation of weir crest	149.0 m
	Gate quantity	3 sets
5	Power Intake and Waterways	
5.1	Intake structures	

	Project Component	Description/Specification
	Overall width (with middle pier)	55 m
	Height	55 m
6	Powerhouse	
	Type	ground
	Rated capacity	250 MW
	Dimension (L x W x H)	85.41m*39.28m*51.2m
7	Generating Equipment	
7.1	Model of water turbine	HL()-LJ-340
	Quantity	3 sets
	Rated output	87.18 MW
7.2	Model of generator	SF85-28/7650
	Quantity	3 sets
	Rated capacity	85 MW
8	Switchyard and Transmission Facility	
8.1	Switchyard	
	Type	GIS
	Area (L x W)	49.57m*11.5m
8.2	Transmission Line	
	Transmission voltage, double circuit	138 kV
	Length of transmission line	20 km
9	Access Road	Length 15.3 km, width 6 m

B. Process Documentation

1. Brief Summary of the Project's EIA Process

The Pulangi Hydopower Corporation (PHPC) commissioned Lichel Technologies Inc. (LTI) to conduct the Environmental Impact Assessment (EIA) for their proposed South Pulangi Hydroelectric Power Plant Project located in the Municipalities of Damulog, Kibawe, Dangcagan and Kitaotao all in the Province of Bukidnon. The conduct of the EIA was guided by relevant issuances of the Department of Environment and Natural Resources (DENR) and the Environmental Management Bureau (EMB) including, but not limited to, DAO 2003-30, MC 2010-14, EMB MC 2014-005 and DENR DAO 2017-15 and its Implementing Rules and Regulations. Proponents of Environmentally Critical Projects (ECPs) must conduct an EIA and submit an Environmental Impact Statement (EIS) or Environmental Performance Report and Management Plan (EPRMP) for review and approval by the DENR through the Environmental Management Bureau (EMB) prior to the issuance of the Environmental Compliance Certificate (ECC).

2. EIA Team

The key members of the multi-disciplinary team who conducted the EIA study and their fields of expertise are shown in **Table ES 2** below:

Table ES 2: EIA Team

	NAME	SPECIALIZATION	REGISTRATION NO.
1.	Rachel A. Vasquez	Project Director/Peer Reviewer/Air Quality/ Water Quality	IPCO-280
2.	Emmanuel Cleofas	Socioeconomics/People	IPCO-277
3.	For. Jan Paolo Pollisco	Terrestrial Flora and Fauna	IPCO 276
4.	Dr. Roberto Pagulayan	Freshwater Ecology/Fisheries/Aquatic Resources	
5.	Engr. Franklin D. Ramones	Hydrology/Hydrogeology/ Agriculture	
6.	Dr. Perfecto Evangelista	Soils and Land Use	IPCO-179
7.	Ronald Pahunang	Meteorology, Air Quality	IPCO-173
8.	Anacleto Suelto, Jr.	Geology/Geological Hazards/Disaster Risk Reduction/EGGAR	
9.	Rainier D. Reyes	Peer Reviewer/Water Quality	IPCO-104
10.	Allen B. Villanueva	Climate Change	IPCO-279
11.	Lynnette Lyzelle Ferrer	Biology/ Aquatic Resources	IPCO-275

3. EIA Study Schedule

Table ES 3 below shows the study schedule. Initial IEC Activities were conducted last August 2018. The Public Scoping was conducted last September 4, 2018. The Scoping meeting with the Environmental Management Bureau was conducted last September 25, 2018.

Table ES 3: EIA Study Schedule

Module	Activity	Date
Pre-Scoping/ Scoping Activities	Initial IEC	July 26, 2018 August 7-8, 2018
	Public Scoping	September 4, 2018
	Technical Scoping with EMB	September 25, 2018
Land	Soil Sampling	August 26-29, 2018
	Geological Survey	September 5-6, 2018

Module	Activity	Date
	Terrestrial Ecology	August 26-29, 2018
Water	Water Quality	September 5-6, 2018
	Hydrology	August 20-21, 2018
	Water Ecology	August 20-21, 2018
Air	Air Quality and Noise Sampling	September 5-6, 2018
People	Household Surveys and Secondary data collection	August 17-24, 2018

4. EIA Study Area

The study area covers the identified direct impact areas such as the location of the proposed damsand the reservoir area. The study covers the Municipalities of Damulog, Kibawe, Dangcagan and Kitaotao, all in the Province of Bukidnon.

5. EIA Methodology

Environmental studies focused on the identified location of each component as the direct impact area. All information and data gathered were compiled and analyzed based on the Guidelines of DAO 03-30. Field investigations and sampling were conducted, together with the secondary data gathered, and the critical parameters for the environmental conditions were established.

The EIA methodology for each study modules are provided in Section 2 and are summarized in **Table ES 4** below**.**

Table ES 4: Methodology Used for each Module

<table>
<tr><th>Modules</th><th>Methodologies Used for Assessment</th></tr>
<tr><td>Geology</td><td>Secondary data gathering from different offices and institutions (e.g., Mines and Geosciences Bureau)
Site visit;</td></tr>
<tr><td>Soils</td><td>Secondary data gathering from different offices and institutions
Sampling conducted by sub-stratum
Parameters analyzed include pH, OM, K, P, N, Cd, Pb, Hg, As, CR $^{6+}$

<table><tr><td>Parameter</td><td>Method</td></tr><tr><td>pH</td><td>Electrometric</td></tr><tr><td>Potassium</td><td>Flame AAS</td></tr><tr><td>Phosphorus</td><td>Colorimetric</td></tr><tr><td>Organic Matter</td><td>Walkley-Black</td></tr><tr><td>Nitrogen</td><td>kjeldahl</td></tr><tr><td></td><td></td></tr><tr><td>Cadmium</td><td>Flame AAS</td></tr><tr><td>Lead</td><td>Flame AAS</td></tr><tr><td>Mercury</td><td>Cold Vapor AAS</td></tr><tr><td>Arsenic</td><td>GF/AAS</td></tr><tr><td>Chromium (Cr 6+)</td><td>Diphenylcarbazide</td></tr></table></td></tr>
<tr><td>Land Use</td><td>Secondary data gathering from Comprehensive Land Use Plan, National Commission on Indigenous People and Proponent
Site visit</td></tr>
<tr><td>Terrestrial Flora</td><td>Transect survey
Secondary data from relevant sources</td></tr>
<tr><td>Terrestrial Fauna</td><td>Transect line survey
Interviews
Secondary data from the relevant sources s</td></tr>
<tr><td>Hydrology</td><td>Stream flow measurement
Secondary data gathering from different offices and institutions
Secondary data used for flood peak prediction</td></tr>
<tr><td>Water Quality</td><td>In situ measurement of water temperature and DO parameters Orion Oxygen Meter (Model 840)

Parameter — Methodology
Total Suspended Solids (TSS) — Grab sampling</td></tr>
</table>

Modules	Methodologies Used for Assessment	
	Oil and Grease	Grab sampling
	Biochemical Oxygen Demand (BOD)	Grab sampling
	Dissolved Oxygen (DO)	Multi-parameter meter
	Temperature	Multi-parameter meter
	pH	Multi-parameter meter
	Total Dissolved Solids (TDS)	Multi-parameter meter
	Salinity	Multi-parameter meter
	Conductivity	Multi-parameter meter
Freshwater Ecology	a. Riparian, Channel, and Environmental Inventory done using the metrics of Petersen (1992) b. Plankton sample collection was done using a plankton net of 80 µm mesh size. c. Riverside macroinvertebrate sampling was done using an improvised 1 mm mesh sieve d. Fish and macro-biota were done on wadable areas with the help of local fisherfolk using cast nets, e. line, or hand sieves, where applicable. f. Interview with local fisherfolk g. Secondary literature search	
Air Quality	High Volume Sampler for TSP sampling, Gas Bubble Sampler. Sound level meter for noise/sound level determination Secondary data from PAGASA for climatic conditions	
Socio-economic	Secondary data gathering for demographic analysis Key Informant Interview Household and Perception Interview Land Acquisition and Resettlement Plan-FGDs, Inventory of Assets; IPDP-FGDs, Interviews, site visits at sacred sites.	

6.

7. Scoping and Public Participation

i. IEC Activities

Table ES 5 below shows the summary of IEC and public participation activities conducted. Summary of the issues and concerns raised during the IEC activities is further discussed in **Section 2.4.7**

Table ES 5: Summary of IEC Activities

Date	Activity	Venue	Participants
July 24, 2018	Project Presentation (LGU-PHPC initiated)	Maramag Gymnasium, Maramag Bukdinon	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders
August 7, 2018 9:00 am	Project Presentation EIA Process Presentation	Function Hall, Municipality of Damulog	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads
August 7, 2018 1:00 pm	Project Presentation EIA Process Presentation	Municipal Gymnasium, Municipality of Kibawe	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads

Date	Activity	Venue	Participants
August 8, 2018 9:00 am	Project Presentation EIA Process Presentation	Lucky 9 Resort Municipality of Dangcagan	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads
August 8, 2018 1:00 pm	Project Presentation EIA Process Presentation	Municipal Tennis Court, Municipality of Kitaotao	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads

ii. Public Scoping

The Public Scoping for the proposed South Pulangi Hydroelectric Power Plant Project was held last September 4, 2018 at the East Kibawe Covered Court in the Municipality of Kibawe, Bukidnon. Around 64 attendees were present during the activity. The Public Scoping Repor is attached as **Annex 9.** Present during the scoping are the following representatives:

- Hon. Minerva Casinabe, Mayor, Municipality of Kibawe
- MENRO, Municipality of Dangcagan
- MPDC, Municipality of Dangcagan
- SB Secretary, Municipality of Dangcagan
- Barangay Affairs Office, Municipality of Kitaotao
- MPDC, Municipality of Kitaotao
- Punong Barangay
    - Dolorosa, Dangcagan
    - Miaray, Dangcagan
    - San Vicente, Dangcagan
    - Balintawak, Kibawe
    - Bukang Liwayway, Kibawe
    - Magsaysay, Kibawe
    - Mascarinas, Kibawe
    - Natulongan, Kibawe
    - Pinamula, Kibawe
    - Sanipon, Kibawe
    - Talahiron, Kibawe
    - Tumaras, Kibawe
    - Cagawasan, Kibawe
    - Kitaihon, Kitaotao
    - Kitobo, Kitaotao
    - Metebagao, Kitaotao
    - San Lorenzo, Kitaotao
- Senior Citizen's Organization
- Magsaysay Elementary School Kibawe
- Department of Energy
- Tribal Chieftain/IPMR
    - Dolorosa, Dangcagan
    - Miaray, Dangcagan
    - San Vicente, Dangcagan
    - Bukang Liwayway, Kibawe
    - Bukang Liwayway, Kibawe
    - Cagawasan, Kibawe
    - Mascarinas, Kibawe
    - Pinamula, Kibawe
    - Talahiron, Kibawe
    - Balocbocan, Kitaotao
    - Kitobo, Kitaotao
    - Metebagao, Kitaotao
    - Tandong, Kitaotao
    - Tangkulan, Damulog

- National Irrigation Administration Bukdinon IMO
- Environmnetal Management Bureau 10

C. EIA Summary

a.) Summary of Alternatives

Table ES 6 shows the summary of alternatives considered for the project in terms of siting and dam type. This is further discussed in **Section 1.3.**

Table ES 6: Summary of Project Alternatives

Positive Feature	Negative Feature
Siting	
Municipality of President Roxas, North Cotabato (Pulangi V)	
Higher project production (300MW)	Larger reservoir area; Higher number of affected household; Political uncertainty
Municipality of Damulog, Province of Bukidnon (South Pulangi HEPP)-**adopted as project**	
Smaller reservoir area, hence less affected households; More favourable political situation	Lower project production (250MW)
Dam Type	
Embankment with Core	
Accepts poor quality but low cost fill material from excavations	Impervious material source uncertain
Appropriate for weak foundation	Wide base requires longer diversion and power tunnels
Least Foundation treatment	Need most protection during construction
Conventional, conservative, ample precedent	
Conclusions: rejected, based on technical	
CFRD	
Least affected by rainfall during construction	Needs substantial volume of imported hi-cost rock fill
Shorter waterways (than embankment with core)	Foundation treatment at plinth grout cap very critical
	Unprecedented for these weak foundations and materials
Conclusion: adopted, basic project	
Hard fill	
Accepts poor quality and low cost aggregates	Unprecedented for this size and combination of conditions
Appropriate for weak foundation	Needs more foundation treatment (than embankment with core)
Least cost for appurtenant structures	Less suited to higher reservoir FSL (dam heights)
Non-erodible and less sensitive to foundation treatment (than CFRD)	Estimated cost least certain.
Conclusion: potential alternative at lower FSL	

b.) Summary of Main Impacts

The summayr of main impact, mitigating and enhancement measures and residual impacts is shown Table ES 7. Project impacts are further discussed in **Section 3.**

Table ES 7: Summary of Main Impacts

Impact	Options for Prevention for Mitigation or Enhancement	Residual Impacts After Mitigation
CONSTRUCTION		
- Vegetation loss	- Avoid unnecessary cutting of vegetation - Inventory of biota and riparian zone as	Clearing of vegetation unavoidable due to nature of

Impact	Options for Prevention for Mitigation or Enhancement	Residual Impacts After Mitigation
- Habitat fragmentation	basis for species and volume replacement - Compensate through planting indigenous tree species suitable in the area - Implement watershed Management Plan	project; ensure implementation of watershed management plan.
- Change in topography - Increased landslides	- Use contour- trenching, furrowing, terracing, ripraps and vegetative measures - Limit construction activities during dry season -Adequate positioning of stockpile areas away from river/creek. - Road-bank soil erosion prevention/minimization (use of biological or non-biological structures)	Possible minimal soil erosion even with soil erosion control measures, Considering the nature of the project, damage is inevitable; rehabilitation after construction should be done.
- Increased soil erosion		
Destruction or disturbance of aquatic life due to works in rivers. Degradation of aquatic habitat, species decline		
Change in river depth and width		
Oil and grease leaks from heavy equipment and vehicles	Periodic inspection and maintenance of equipment	Possible minimal spill even with appropriate storage and management
Change in river depth and width Change in river flow Increased Siltation and Sedimentation	- Provision of diversion structures to prevent blockage of river flow	Due to nature of project, change in river depth at the reservoir inevitable.
Change in species richness due to decrease water flow		
Permanent and temporary dislocation of households and loss/destruction of properties, trees, and crops.	Implementation of mutually acceptable compensation scheme Implementation of an IEC program	Displacement of houses is unavoidable considering the nature of the proposed project.
Temporary to permanent physical alteration of site where construction work is to be done dam	Minimize disturbances and proper disposal of spoils	Physical alteration is inevitable due to impounding of water/reservoir.
Reduced biodiversity because of direct habitat alteration or effect of siltation and secondary disturbances; Reduced productivity and upstream-downstream transit of organism in the vicinity of construction area.	Minimize direct disturbance, even allowing a portion of the river to be open for organism transit; minimize all forms of direct and indirect waste discharge to the river water. Compensation from lost and reduction of productivity of harvested aquatic organisms may be in order.	
OPERATIONS		
Prevent/control flooding	Adequate release of water during heavy rainfall Implementation of emergency response plans and safety procedures	Project area is located in area with high landslide susceptibility. Landslide possible even with application of mitigating measures.
Increase in landslides in reservoir area		
Employment opportunities	Prioritization of host communities in employment	Employment is possible as long as the project is in operation

Impact	Options for Prevention for Mitigation or Enhancement	Residual Impacts After Mitigation
Increased source of livelihood for locals	Assistance to LGUs in formulation and implementation of alternative sources of livelihood	
ABANDONMENT		
Land and water pollution	Allocate certain percentage of the construction cost for clean-up after construction - Salvage materials that are usable which can be used by the local workers or residence	Contamination of land and soil during clean up still possible even with mitigating and management measures.
Loss of species richness	-Continual rehabilitation and re-vegetation of idle and barren lands using indigenous species.	Due to nature of project, restoration to pre-project conditions may not be possible.
Riverbanks stabilization through engineering measures and/or regreening technologies	Community-based regreening and maintenance could be instituted	Due to nature of project, restoration to pre-project conditions may not be possible.
Allow enough time for organisms to repopulate the altered environment	Compensation or provision of alternative source of income could be provided.	Due to nature of project, restoration to pre-project conditions may not be possible.

c.) Risks and Uncertainties

The Environmental Impact Statement was prepared based on the latest available information and as a result of the different scenario analysis, modeling and comparison with standards. This should serve as guide to local, regional and national decision makers in decisions concerning project-related activities. However, this should not be the sole basis of decision making since it is possible that there are project-related risks that is not within the scope of this assessment and may not have been considered in the related management plans. Hence, this assessment will only help as a guide and as supplement to the wide array of information available to decision makers.

In the determination of risks and uncertainties, natural and man-made hazards were assessed to aid decision makers in reducing risks for the multipurpose project. Natural hazards with high susceptibility include ground motion, Earthquake induced landslides, seiche, mass wastingand fluvial hazards.

1 PROJECT DESCRIPTION

1.1 Project Location and Area

1.1.1 Project Location

The proposed South Pulangi Hydroelectric Power Plant project is located in the Municipalities of Dangcagan, Damulog, Kibawe, and Kitaotao, all in the Province of Bukidnon. The proposed dam for the project is located across Pulangi River while the proposed powerhouse is situated approximately 300 meters from the dam.

The river headwaters are located to the south of Kalatungan Mountain, Kitanglad Mountains in the west and Mount Amaloi in the east. Its subwatershed natural vegetation is characterized by declivitous areas and deep gorge which include Tigua, Sawaga, Kulaman, Aracan and Mulita watersheds. The Pulangi River headwaters are located to the south of the Kalatungan Mountain, Kitanglad Mountain, in the west and Mount Amaloi in the east. About 70km from the farthest north headwater in the eastern portion of the basin, the river turns to the west near Kalatungay and enters a broad plain south and east of Kalatungan mountain before turning south again and flowing into the Pulangi IV reservoir near Maramag. Downstream of Pulangi IV reservoir, it continues south for a hundred kilometer then turns to the west and enters the Mindanao Sea at Illana Bay near Cotabato City. In the North West quadrant, the Pulangi River watershed borders the Cagayan River. The drainage divide is the height of the land at the near slope of Kitanglad and Kalatungan Mountains.

The proposed dam and the power house for the proposed project are located in the following coordinates, all in the Municipality of Damulog (**Table 1-1**):

Table 1-1: Project Location

Project Component	N	E
Dam	7° 25’ 36.84”	125° 02’ 17.96”
Power House	7° 25’ 30.87”	125° 02’ 26.83”

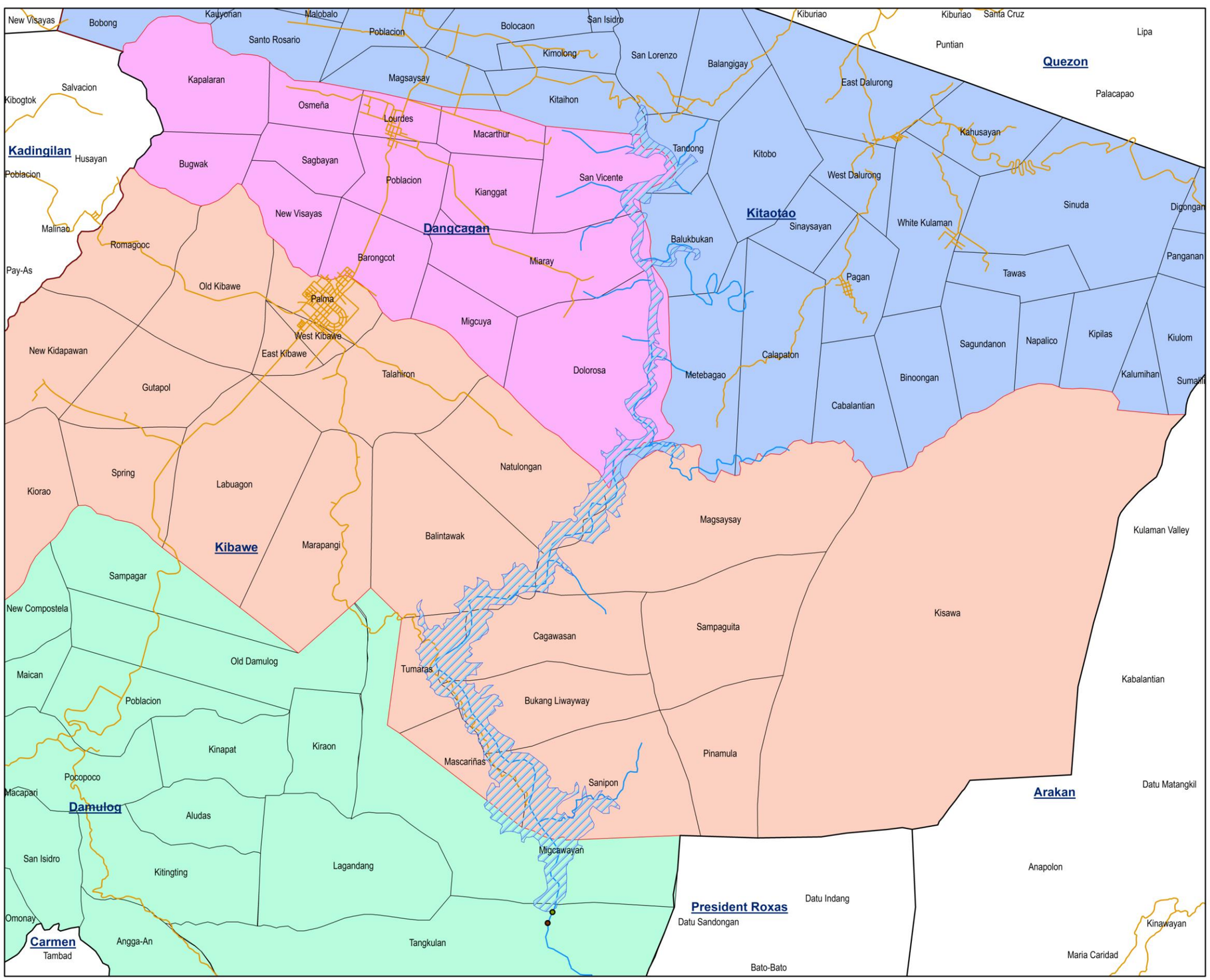
The project’s reservoir area at normal storage capacity is at 29.24 km^2 with an elevation of 165 m. The reservoir capacity at normal storage capacity is at 1169.3 10^6 m^3. Aerial photograph of the Project site is shown as **Figure 1-1.**

1.1.2 Accessibility of Project Site

The proposed project site is approximately 13km from the center of the Municipality of Damulog and approximately 17km from the center of the Municipality of Kibawe. Both municipalities are in the Province of Bukdinon, accessible via 3-hour ride from Davao City or 3-hour ride from Cagayan de Oro City. The project site is accessible from the national highway from the Municipality of Kibawe via barangay roads. A short boat ride from Barangay Mascarinas to Barangay Tangkulan is necessary to reach the dam site. The alternative is a 1.5-hour hike from Brgy Mascarinas to the Project Site (**Figure 1-1**).

1.1.3 Direct and Indirect Impact Areas

Section 10 of DENR Administrative Order 15 series of 2017 provided guidelines on defining DIA for the impact on land, water, air and people Based on these guidelines, the direct and indirect impact areas were delineated. For impacts on land, this includes areas that may be inundated and may experience habitat disturbance (reservoir area). For water, this includes portions of water bodies that traverses the project (Pulangi River, dam area and power station) and may be affected during construction.



Author: Lichel Technologies Inc

Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree

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FIGURE TITLE :

Project Location Map

FIGURE NO.:

1-1

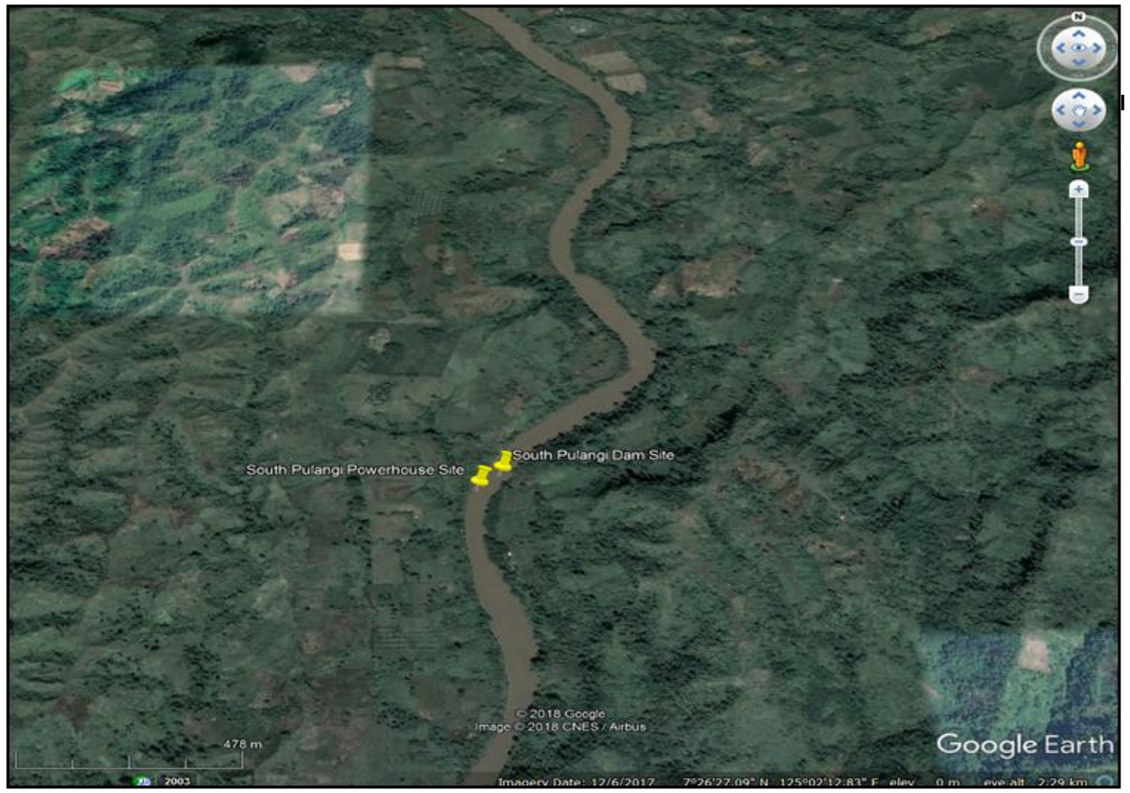

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FIGURE TITLE :

Aerial Photo of Project Site

FIGURE NO.:

1-2

For the people component, identified DIA are the barangays where the facilities are located and the settlements near/within the proposed facilities which may necessitate involuntary relocation and settlements that might experience competition in resource use with the project. Considered as IIA in the assessment are the remainder of municipalities where the DIA barangays are located since the impacts (positive and negative) will have a corresponding effect on these municipalities.

1.2 Project Rationale

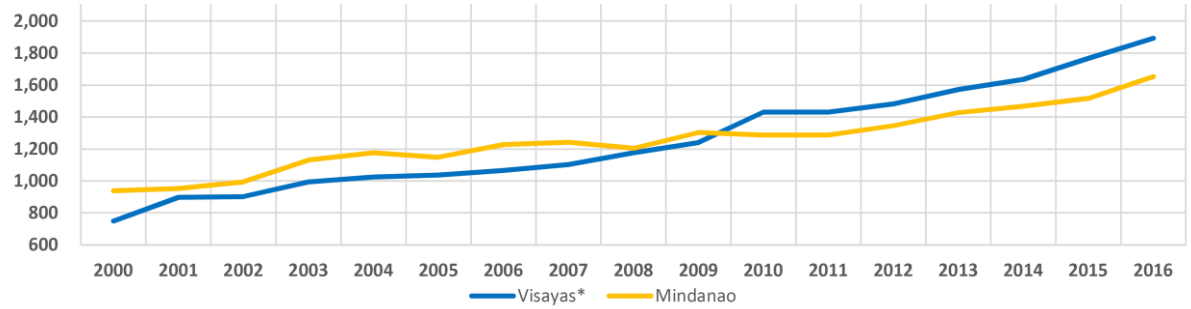
- **The Project will contribute to meet the energy demand of Mindanao.**

The project is envisioned to supplement the power needs of Mindanao. **Table 1-2** and **Figure 1-3** shows the annual peak system demand per grid. Records show that between 2008 and 2017 (10-year period) peak system demand for Mindanao has increased annually by 3.6%. In contrast, peak system demand for Mindanao for the last 5 years (2013-2017) has been increasing by 5.5% annually. Further, **Table 1-3** shows the installed generating capacity for the Mindanao Grid for 2013-2017. As of 2017, records show that coal generating plants account for 38.5% of the installed generating capacity for Mindanao while hydropower accounts for 30.4%. With the project, it is expected that to increase the generating capacity of hydropower in particular and renewable energy in general. In addition, **Figure 1-4** shows the power demand for Mindanao. Based on records from DOE, Mindanao will need an additional 3,650 MW by 2021-2030 to meet its power demand based on an average annual growth rate of 7.6%.

Table 1-2: Annual Peak System Demand per Grid 2000-2017 in MW

Year	Luzon	% GR	Visayas*	% GR	Mindanao	% GR	Total Non-Coincident Peak Demand (Max)	% GR
2000	5,450	9.3	749	2.7	939	5.3	7,138	8.0
2001	5,646	3.6	898	19.9	953	1.5	7,497	5.0
2002	5,823	3.1	903	0.6	995	4.4	7,721	3.0
2003	6,149	5.6	995	10.2	1,131	13.7	8,275	7.2
2004	6,323	2.8	1,025	3.0	1,177	4.1	8,525	3.0
2005	6,443	1.9	1,037	1.2	1,149	(2.4)	8,629	1.2
2006	6,466	0.4	1,066	2.8	1,228	6.9	8,760	1.5
2007	6,643	2.7	1,102	3.4	1,241	1.1	8,987	2.6
2008	6,674	0.5	1,176	6.7	1,204	(3.0)	9,054	0.7
2009	6,928	3.8	1,241	5.5	1,303	8.3	9,472	4.6
2010	7,656	10.5	1,431	15.3	1,288	(1.2)	10,375	9.5
2011	7,552	(1.4)	1,431	0.0	1,288	0.0	10,271	(1.0)
2012	7,889	4.5	1,481	3.5	1,346	4.5	10,716	4.3
2013	8,305	5.3	1,572	6.1	1,428	6.1	11,305	5.5
2014	8,717	5.0	1,636	4.1	1,469	2.9	11,822	4.6
2015	8,928	2.4	1,768	8.1	1,517	3.3	12,213	3.3
2016	9,726	8.9	1,893	7.1	1,653	9.0	13,272	8.7
2017	10,054	3.4	1,975	4.3	1,760	6.5	13,789	3.9
%AAGR								
2008-2017		4.3		6.1		3.6		4.4
2013-2017		5.0		5.9		5.5		5.2

Source: DOE 2017 Power Statistics



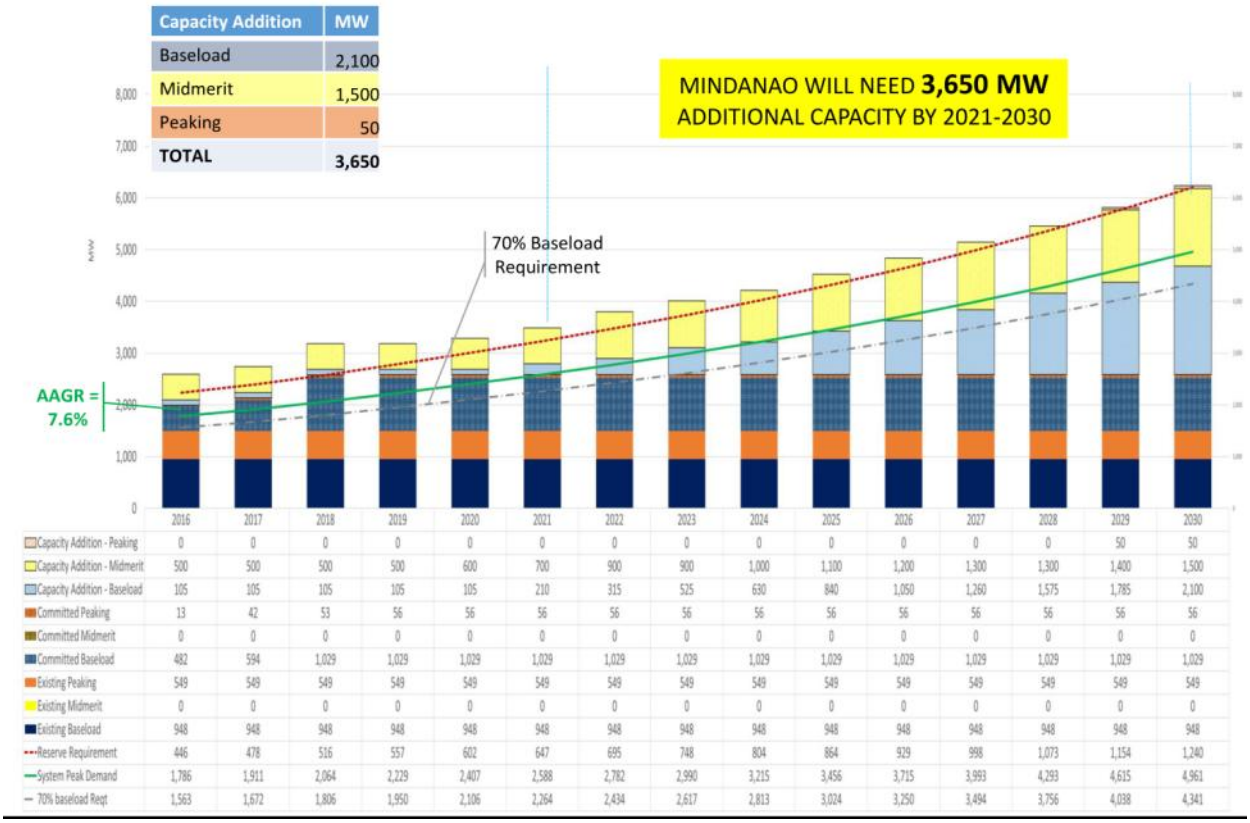
Source: DOE 2017 Power Statistics

Figure 1-3: Annual Peak System Demand Visayas and Mindanao Grid 2000-2016 in MW

Table 1-3: Installed Generating Capacity (Mindanao Grid)

Source	2013	2014	2015	2016	2017	% Share (2017)
Coal	**232**	**232**	**382**	**1,070**	**1,370**	**38.5**
Oil-Based	**663**	**773**	**807**	**828**	**906**	**25.5**
Natural Gas	**0**	**0**	**0**	**0**	**0**	**0**
Renewable Energy	**1,192**	**1,206**	**1,225**	**1,264**	**1,284**	**36.1**
Geothermal	*108*	*108*	*108*	*108*	*108*	*3.0*
Hydro	*1,047*	*1,061*	*1,061*	*1,061*	*1,080*	*30.4*
Biomass	*36*	*36*	*36*	*36*	*36*	*1.0*
Solar	*1*	*1*	*20*	*59*	*59*	*1.7*
TOTAL	**2,087.00**	**2,211.00**	**2,414.00**	**3,162.00**	**3,560.00**	**100.0**

Source: DOE 2017 Power Statistics



Source: Presentation on the Mindanao Power Situation and Outlook

Figure 1-4: Mindanao Power Demand

- **The Project will contribute in minimizing flooding.**

The project will help in controlling the flooding downstream up to Rio-Grande River being discharged in Cotabato City and other downstream areas. With the forecasted rain fall, the proposed project could generate more electricity to lower active storage capacity. Thus, this will increase the expected storage capacity of the dam or the volume of water to be stored in the dam

- **The Project will contribute in siltation control.**

Lastly the proposed project will provide control of siltation. The dam will have a dead storage capacity of 495 million cubic meters which could be filled of sediment coming from up stream. At present rate of 8 million cubic meters per year, the dead storage could be filled up to 62 years, which is beyond the normal lifetime of a hydropower plant of 50 years.

1.3 Project Alternatives

1.3.1 Siting

Two possible locations for the dam site were considered. Initially, under the proposed Pulangi V HEPP Project, the proposed dam site would be situated around 7 km downstream in the Municipality of President Roxas, North Cotabato. However, due to the political situation, the number of households that will be affected by the reservoir and the geology of the site, an alternate site were considered. The current proposed site provides a more favorable political situation, fewer households to be affected and a considerably more favorable geology to construct the dam, the current site is now being currently considered for the location of the project.

1.3.2 Development Design

Table 1-3 shows the three (3) types of dam considered for the project and the basis for the selection of dam type which is an embankment with hard core.

Table 1-3: Comparison of Dam Types

Positive Features	Negative Features
Embankment with Core	
Accepts poor quality but low cost fill material from excavations	Impervious material source uncertain
Appropriate for weak foundation	Wide base requires longer diversion and power tunnels
Least Foundation treatment	Need most protection during construction
Conventional, conservative, ample precedent	
Conclusions: rejected, based on technical	
CFRD	
Least affected by rainfall during construction	Needs substantial volume of imported hi-cost rock fill
Shorter waterways (than embankment with core)	Foundation treatment at plinth grout cap very critical
	Unprecedented for these weak foundations and materials
Conclusion: adopted, basic project	
Hard fill	
Accepts poor quality and low cost aggregates	Unprecedented for this size and combination of conditions
Appropriate for weak foundation	Needs more foundation treatment (than embankment with core)
Least cost for appurtenant structures	Less suited to higher reservoir FSL (dam heights)
Non-erodible and less sensitive to foundation treatment (than CFRD)	Estimated cost least certain.
Conclusion: potential alternative at lower FSL	

1.3.3 Resource

Rockfill Material Sources

Borrow materials to be used for the project will be sourced along Pulangi River. **Table 1-4** and **Figure 1-5** shows the indicative location of the sources of burrow material for the project. There are eight (8) locations identified for the project.

Table 1-4: Sources of Borrow Material for the Project

	Location of Quarry	Description of Location	E	N
1	Sandstone	1 km downstream right bank of dam	125°02'03.77"	7°25'45.61"
2	Basalt	10 km upstream right bank of dam	125°01'29.84"	7°31'17.91"
3	1# Limestone	upstream of reservoir	125°03'25.34"	7°37'01.64"
4	2# Limestone	downstream of Pulangi IV HEPP,near Davao-Bukidnon Hwy	125°01'51.76"	7°42'17.71"
5	1# sand and gravel borrow area	1.2 km downstream left bank of dam	125°02'21.64"	7°25'34.38"
6	2# sand and gravel borrow area	2 km upstream dam left bank	125°02'24.95"	7°27'04.65"
7	3# sand and gravel borrow area	7 km upstream right bank of dam	125°01'03.40"	7°29'38.27"
8	Soil borrow area	1 km upstream right bank of dam	125°02'02.85"	7°26'49.53"

Water Sources

Water source during construction will be mostly from Kibawe Water District which supplies the domestic water needs in the project area. If necessary spring and ground water sources may also be developed absed on the needs of the project. Necessary permits will be secured prior to development of alternative water source.

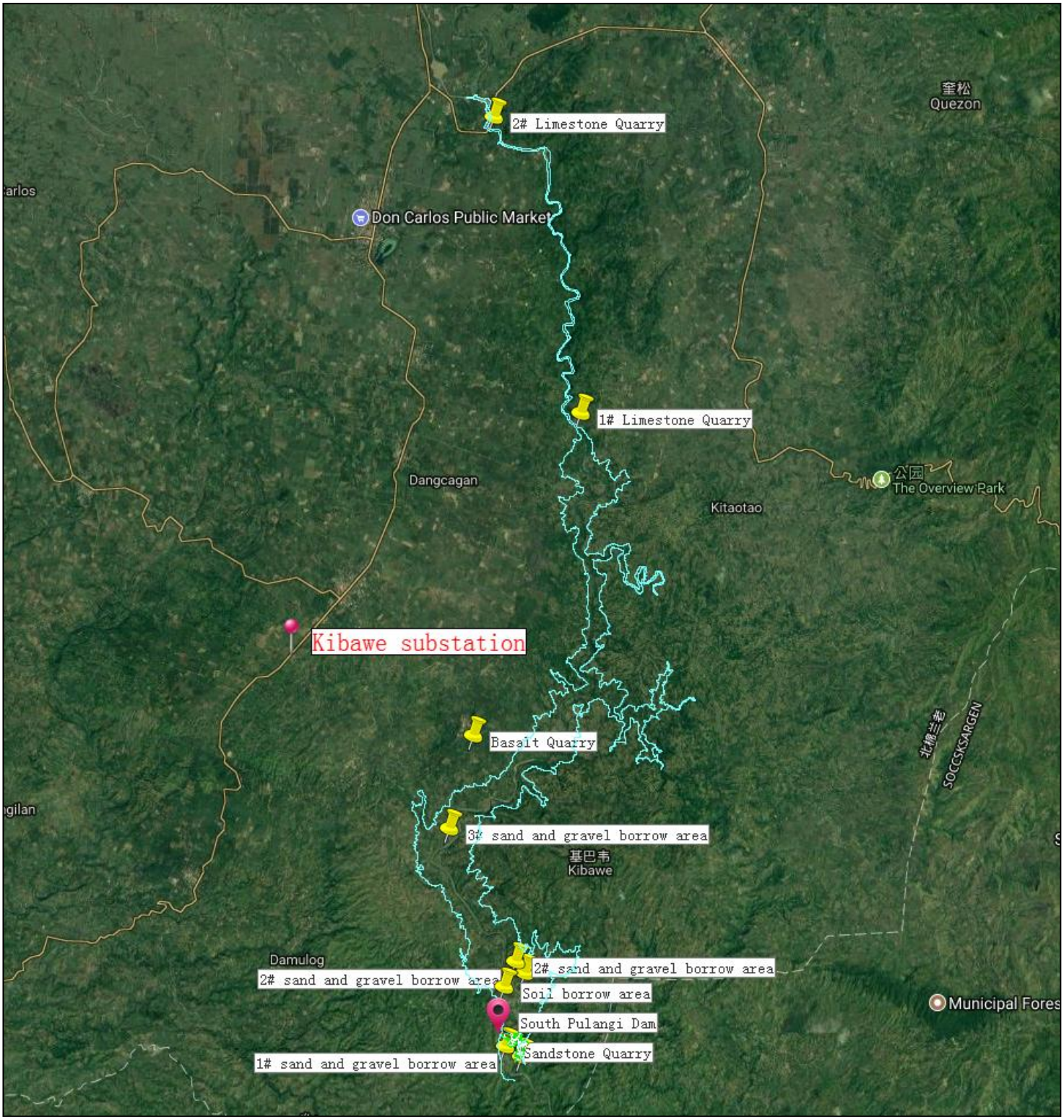
Power Sources

The power/electricity need of the project area is serviced by the First Bukidnon Electric Cooperative, Inc. (FIBECO). During project construction, standby generators may be utilized if needed to supply the power needs of the project activities.

1.3.4 No Project Option

Under a “No Project” scenario, the project is projected to be not implemented. In this scenario, the 250 MW output of the project will not materialize and hence, will be detrimental to the power demand of Mindanao. The inability to pursue the project also runs counter to the government policy on renewable energy. With the current power generation highly dependent on coal and oil-based power sources, the country’s dependence on foreign materials for energy generation will also increase. The project offers locally available power generation material.

In addition, other projected project benefits i.e., royalties, flood control, siltation management, watershed management, benefits under ER 1-94, etc. will not materialize.



Lichel Technologies, Inc. 1403 Prestige Tower Condominium, F. Ortigas, Jr. Road, Ortigas Center, Pasig City	FIGURE TITLE: **Location of Borrow Material Sources**	FIGURE NO. **1-4**

1.3.5 Advantages of the Project

In general, hydropower projects are considered as a clean fuel source as compared to other power sources, meaning it won't pollute the air like power plants that burn fossil fuels, such as coal or natural gas. Hydroelectric power is also a domestic source of energy that will make the country rely less on foreign fuel sources. Impounding reservoir also serves as flood control mechanism which other power source type is not capable of. In some instances, hydropower project serves as multi-purpose project that integrates power generation, irrigation, domestic water supply and aquaculture. For this project, power generation and aquaculture (for livelihood purpose) is expected. (www.energy.gov).

1.4 Project Components

Table 1-5 below shows the summary of project components for the project. The succeeding section describes the identified project components.

Table 1-5: Summary of Project Components

	Project Component	Description/Specificaiton
1	Dam	
	Dam type	Concrete face rockfill dam
	Maximum dam height	143.1 m
	Length of dam crest (including spillway)	878.5 m
2	Reservoir	
	Area	2,924 ha
	Storage capacity	1169.3 10^6 m^3
3	River Diversion and Outlet Facilities	
	Cofferdam Elevation	73 m
	Design Flood	1.5 year return period
	Diversion Tunnel-diameter	10 m
	Number of units	3
	Length	900 m
4	Spillway	
	Elevation of weir crest	149.0 m
	Gate quantity	3 sets
	Aperture dimension of water release sluice (w x h)	16*16 m
5	Power Intake and Waterways	
5.1	Intake structures	
	Overall width (with middle pier)	55 m
	Height	55 m
	Elevation of inlet bottom still	118.5 m
	Quantity of trash rack	3 sets
	Dimension of trash rack	8.5*16.5 mxm
	Gate quantity	1 set
	Gate dimension	10m*10m
5.2	Headrace tunnel	
	Diameter (circular)	8 m
	Length	59 m
5.3	Penstock	
	Quantity	1 set
	Main pipe single length	563 m
	Diameter of steel pipe	8/4.5(main/branch) m
6	Powerhouse	
	Type	ground
	Rated capacity	250 MW

	Project Component	Description/Specificaiton
	Dimension (L x W x H)	85.41m*39.28m*51.2m
	Each control elevation	
	Water turbine installation (vane center) elevation	52.00 m
	Generator floor of engine room	63.90 m
	Water turbine floor	55.30 m
	Elevation of erection bay	69.90 m
	Foundation bottom	39.10 m
	Bottom plate of tailrace tube	41.60 m
	Elevation of bridge crane tread	84.90 m
7	Generating Equipment	
7.1	Model of water turbine	HL()-LJ-340
	Quantity	3 sets
	Rated output	87.18 MW
	Rated revolution	214.3 r/min
	Maximum working head	112.3 m
	Minimum working head	61.5 m
	Rated head	95 m
	Rated flow	98.5 m^3/s
7.2	Model of generator	SF85-28/7650
	Quantity	3 sets
	Rated capacity	85 MW
	Rated power factor	0.85
	Rated voltage	13.8 kV
	Model of main transformer	SF11-100000/138
	Quantity	3 sets
	Capacity	100000 kVA
	Voltage ratio	138±2x2.5%/13.8 kV
	Model of in-plant crane	160+160/32/10t
	Span	22 m
	Lifting capacity	320 t
8	Switchyard and Transmission Facility	
8.1	Switchyard	
	Type	GIS
	Area (L x W)	49.57m*11.5m
8.2	Transmission Line	
	Transmission voltage, double circuit	138 kV
	Length of transmission line	20 km
9	Access Road	Length 15.3 km, width 6 m

1.4.1 Dam

The dam site is located across Pulangi River at coordinates 7˚ 25' 36.84" N and 125˚ 02' 17.96" E in Barangay Tangkulan in the Municipality of Damulog, Province of Bukidnon (**Figure 1-6**). Consequently, all of the hydraulic structure will be sited on the right bank. Because of the high flood potential and absence of extended low flood period, a large diversion flood capacity will be constructed.

The project involves the construction of concrete face rockfill dam with a maximum dam height of 143.1 meters and length of 878.5m.

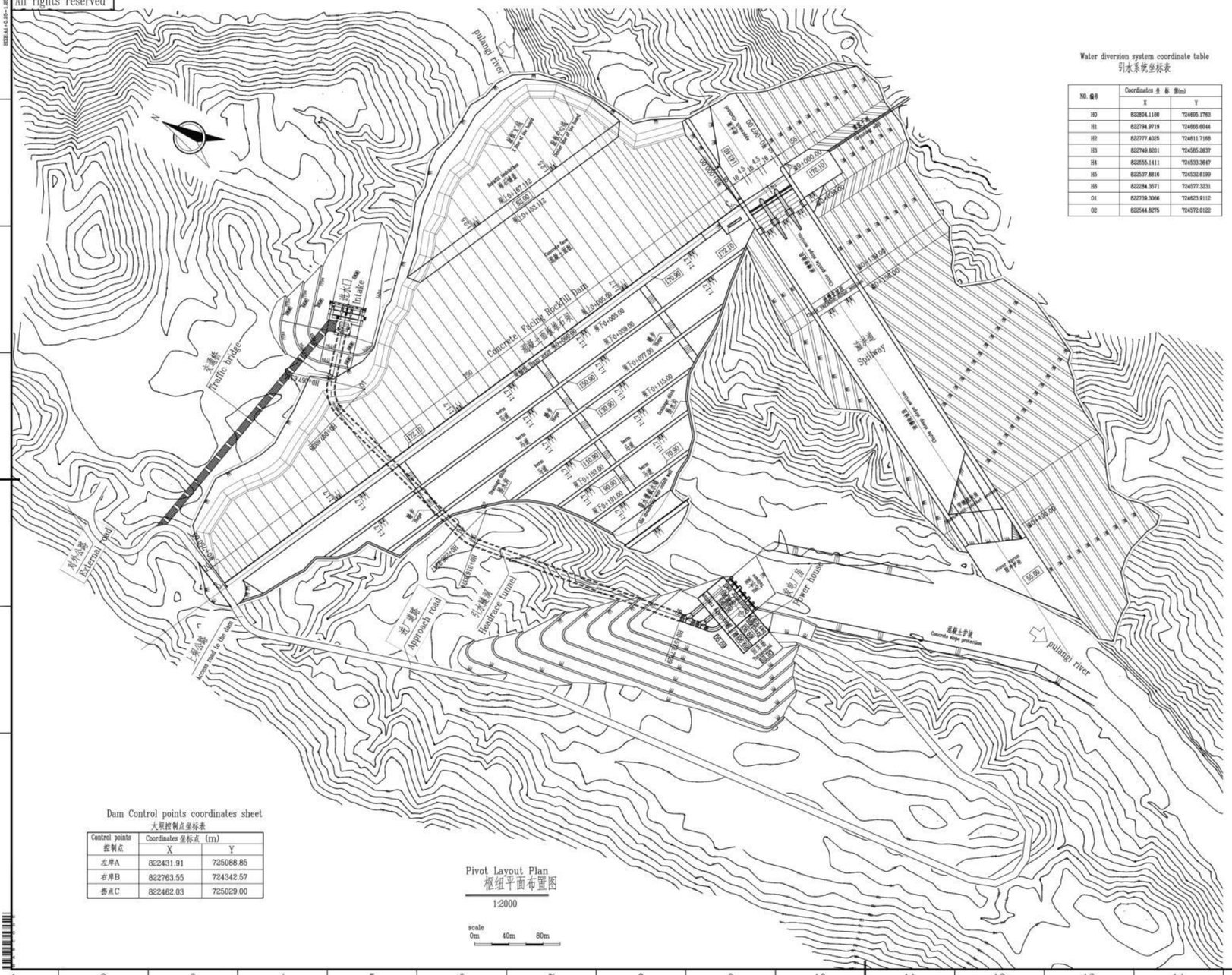
A conservative approach will be adopted with a provision of a blanket of impervious materials under the upstream shell connecting to a fairly narrow central core. Extensive drainage and grouting measures are provided in the abutments due to the horizontally bedded site rocks. In the foundation of the river section, the vertical permeability is as much less than the horizontal. Both fine and coarse transitional drainage zone are provided downstream or the core. The material would come from river alluvium.

The dam is a conventional rockfill embankment with an impermeable earth core and features relatively flat slope to suit both the foundation strength and weak rockfill materials available locally. Most of the fill materials for the shell will come from the required excavations. Core materials is not available locally and will be obtained from borrow area about 200km away. Filter translation and drainage materials will be produced from river alluvial deposits.

The dam shell is largely composed of materials excavated from the quarries in the site rocks and required excavations. In the drawdown zone of the upstream shell, free draining river alluvium will be used. Riprap is assumed to be obtained from quarry area with good quality and site about 7-10 km from the site.

1.4.2 Reservoir

The drainage basin of Pulangi River at the dam site is 3,930 km^2. The reservoir extends upstream about 30 km and has an area of 29.24 km^2 at FSL. At the dam site and its vicinity, the river flows within an almost gorge-like valley whose sides rise 100 meters or so above the river. The sides are rising to about 45^o-75^o slope with many intersecting gullies. The river basin has a diverse nature with some areas subject to the south west and/or northwest monsoon. The site is located within a series of horizontally bedded rock strata varying between conglomerates around the dam crest elevation down through sandstone and silt stone series. There is no faulting in the vicinity of the powerhouse and its facilities including the dam and the reservoir. The Pulangi River channel contains about 10m of alluvium. The rocks are the soft and weak particularly the lowest series at and below the river bed.



Water diversion system coordinate table
引水系统坐标表

NO. 编号	Coordinates 坐 标 值(m)	
	X	Y
H0	822804.1180	724695.1763
H1	822794.9719	724666.6044
H2	822777.4325	724611.7168
H3	822749.6201	724585.2837
H4	822555.1411	724533.3647
H5	822537.8816	724532.6199
H6	822284.3571	724577.3231
O1	822739.3066	724623.9112
O2	822544.8275	724572.0122

Dam Control points coordinates sheet
大坝控制点坐标表

Control points 控制点	Coordinates 坐标点 (m)	
	X	Y
左岸A	822431.91	725088.85
右岸B	822763.55	724342.57
指点C	822462.03	725029.00

工程特性表 ENGINEERING CHARACTERISTICS SHEET

编号 NO	项目 Name	单位 Unit	数值 Quantity
一	水文 Hydrology		
1	流域面积 Catchment area	km^2	3930
2	多年平均流量 Mean Annual reservoir inflow	m^3/s	154
3	多年平均径流量 Mean annual runoff	10^8m^3	48.6
4	洪峰流量 Peak flow		
1)	P=0.2%洪峰流量 Peak flow(P=0.2%)	m^3/s	5164
2)	P=0.01%洪峰流量 Peak flow(P=0.01%)	m^3/s	8392
二	库容特性 Characteristics capacity of reservoir		
1	静库容 Stilling storage	10^8m^3	11.69
2	死库容 Dead srorage	10^8m^3	4.95
3	调节库容 Available storage	10^8m^3	6.75
4	水库调节性能 Reservoir regulation performance	年调节 annual regulation	
三	水库特征水位 Characteristics level of Reservoir		
1	正常蓄水位 Normal Pool Level	m	165.00
2	设计洪水位 Design Flood Level	m	163.95
3	校核洪水位 Check flood Level	m	169.37
4	死水位 Dead Water Level	m	135.00
四	工程动能指标 Momentum indicators		
1	装机容量 Installed capacity	MW	255
2	多年平均发电量 Average annual energy output	GW.h	1117.73
3	年利用小时 Annual utilization hours	h	4383
五	主要建筑物 Main hydraulic structure		
1	坝 dam		
1.1	坝型 Type of dam	混凝土面板堆石坝 Concrete Facing Rockfill Dam	
1.2	坝顶/防浪墙顶高程 Dam crest/Wave protection wall elevation	m	170.90/172.10
1.3	坝顶宽度 Dam Crest width	m	10.00
1.4	坝顶长度 Dam Crest length	m	882.00
1.5	最大坝高 Maximum Dam height	m	143.10
2	溢洪道 spillway		
2.1	溢洪道型式 Type of spillway	开敞式溢洪道 free overflow spillway	
2.2	堰顶高程 Elevation of weir crest	m	149.00
2.3	孔口 Orifice N×B		3×16.00m

3	发电引水系统 Water diversion system		
3.1	进水口 Water intake		
1)	进水口型式 Type of Water intake		岸邻式 bank-lower intake
2)	底板高程 Intake floor elevation	m	118.50
3.2	引水隧洞 Headrace tunnel		
1)	长度 Length	m	55.00
2)	洞径 Diameter	m	8
3.3	压力管道 Penstock		
1)	长度 Length	m	655.00
2)	主管直径 Exposed penstock diameter	m	8
3)	支管直径 Branch pipe diameter	m	4.5
3.4	发电厂房 Hydropower station		
1)	厂房型式 Type		地面式 Surface
2)	主厂房(L×W) Main power house		85.41m×25.30m
3)	副厂房(L×W) Auxiliary power house		85.41m×13.98m
4)	水轮机安装高程 Setup elevation of turbine	m	52.00
六	主要设备 Main equipment		
1	水轮机 Turbine		
1)	台数 Quantity	Unit	3
2)	型号 Specification		HLO-LJ-340
3)	单机额定出力 Rated output	MW	87.18
4)	额定水头 Rated head	m	95
2	发电机 Generator		
1)	台数 Quantity	Unit	3
2)	型号 Specification		SFB5-28/7650
3)	单机额定功率 Rated power	MW	85

说明：
1. 本套图共5张，图号为45380K-052-001~005.
2. 本图尺寸单位：高程和桩号均以m计。

Notes:
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South Pulangi Hydropower station Project		Hydraulic Structure	SECTION
		Feasibility Study	DESIGN
APPROVED		Pivot Layout Plan	
VERIFIED			
EXAMINED			
CHECKED			
DESIGNED			
2017.11	SCALE 1:2000	DRAWING No.	45380K-052-001

Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

Indicative Dam Layout

FIGURE NO.:

1-6

1.4.3 River Diversion and Outlet Facilities

1.4.3.1 Cofferdam

A cofferdam will be constructed prior to the main dam construction. The upstream cofferdam will have a crest at EI 73m and is designed to handle a 1.5 year return period flood during its construction (following initial closure). A jet grout cut-off is processed to allow simultaneous construction with the fill placing. The ability of Pulangi IV upstream to provide some short-term flow regulation would facilitate river closure. A conventional downstream cofferdam will be constructed, no cut-off is necessary since the river bed alluvium can be left in place under the downstream section of the embankment shell. Both cofferdams are incorporated within the embankment.

1.4.3.2 Diversion Tunnels

The diversion channel will be three (3) 10.0 m diameter concrete-lined tunnel averaging 900 m long. For superior support and hydraulic performance, a circular internal section will be adopted. One of the tunnels, the inner most closest to the dam, will be used to house the low level outlet. It will set 5m higher than the 2 tunnels to facilitate initial closure, dewatering and conversion works. The outlet capacity is 300m^3/s at EI 135 m or the minimum operating level (MOL). This is equal to the maximum power plant discharge. This design is also adopted in lowering the average inflow or the reservoir at below EI 110 m within a month under emergency conditions.

1.4.4 Spillway

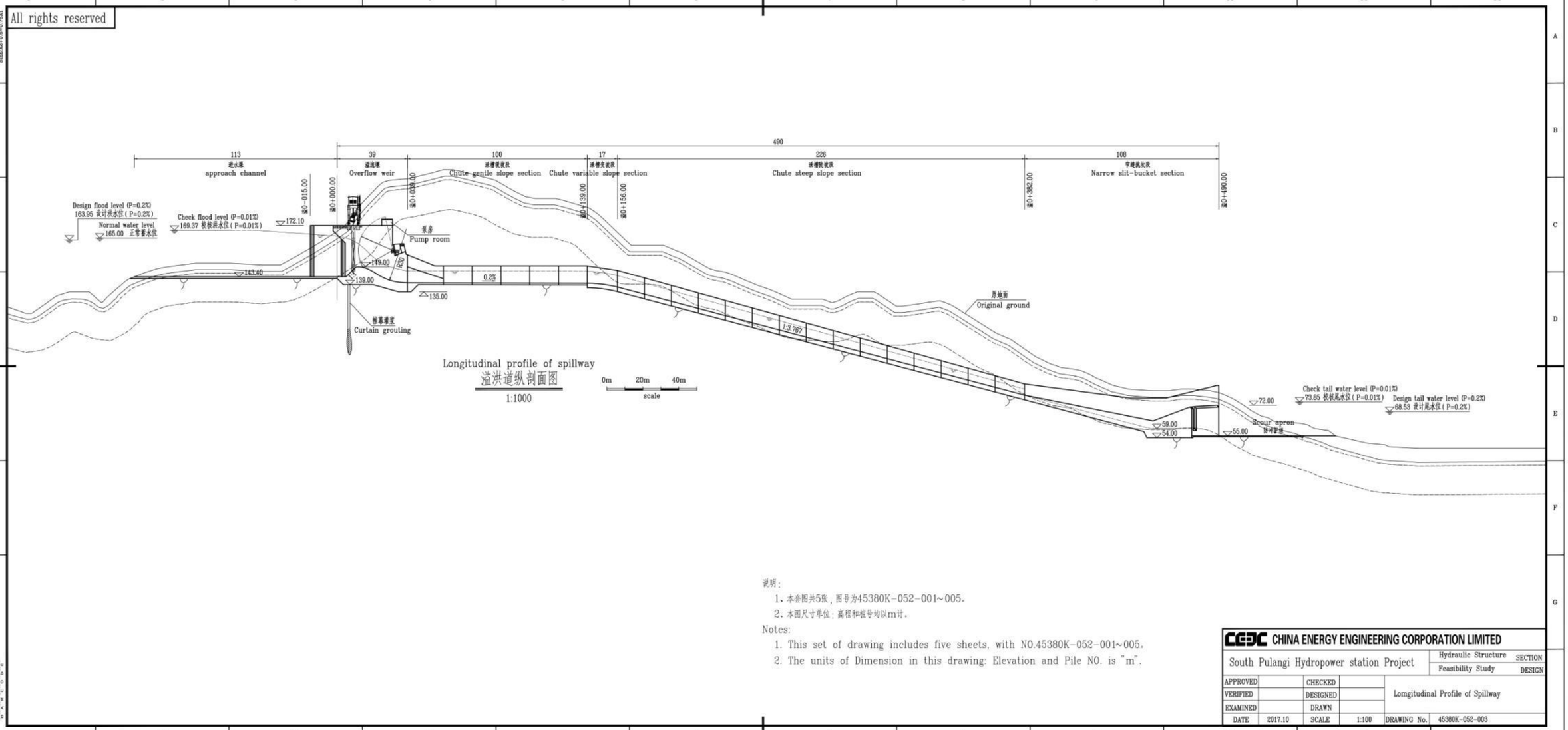
The spill way consists of an entrance channel, a gated crest structure, chute, flip bucket and plunge pool**.** Spillway will have a chute length of 160 m up to the flip bucket and a gross crest width of 91 m. The rest structure is aligned along the main spine of the ridge which extends from the dam abutment. The chute is aligned to direct the discharge toward the pronounced right hand bend in the river. The spillway is located so as to balance the need to minimize excavation: to provide satisfactory channel hydraulics at the merge with the river; and to allow space for the adjacent power facilities and diversion channel outlets.

The crest structure incorporates a conventional ogee over flow section and includes a grouting, drainage and inspection gallery linked to the similar gallery which extends bellow the ridge and to the dam abutment. The structure holds three 16 m wide by 16 m high radial gate. The chute is provided with tow intermediate training walls throughout its length. The underside of the chute is dowelled into the rock and provided with drainage. The flip bucket is unusually massive to ensure stability in the relatively weak rock. The plunge pool is fully concrete-lined to minimize the risk of erosion in the soft rock. A concrete slab covers the scour apron extending from the flip bucket to the pool.

1.4.5 Power Intake and Waterway

The intake is a conventional inclined tower structure supported against the excavated rock face. It houses the normal trash rack service and maintenance gates. The power tunnel is some 260m long with an 8m diameter fully concrete-lined circular section. The waterway is dimensioned for a maximum plant discharge of 300 m^3/s.

A single 75m diameter steel penstock, 250m long of which 60m is inside the power tunnel leads down towards the power house. The penstock is located mostly within an excavated slot and includes a massive support block at the end of the slot where the pen stock drops down to the trifurcation which provide individual 3.55m diameter penstocks. For this next higher pressure section, the diameter is reduced to 7.0m.



Longitudinal profile of spillway

溢洪道纵剖面图

1:1000

0m 20m 40m

scale

说明：

1、本套图共5张，图号为45380K-052-001~005。

2、本图尺寸单位：高程和桩号均以m计。

Notes:

1. This set of drawing includes five sheets, with NO.45380K-052-001~005.
2. The units of Dimension in this drawing: Elevation and Pile NO. is "m".

CEEC CHINA ENERGY ENGINEERING CORPORATION LIMITED

South Pulangi Hydropower station Project		Hydraulic Structure	SECTION
		Feasibility Study	DESIGN

APPROVED		CHECKED		Lomgitudinal Profile of Spillway	
VERIFIED		DESIGNED			
EXAMINED		DRAWN			
DATE	2017.10	SCALE	1:100	DRAWING No.	45380K-052-003

Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

Indicative Spillway Design

FIGURE NO.:

1-7

1.4.6 Powerhouse

The Three-power unit powerhouse is a conventional surface structure where in individual butterfly inlet valve are housed within the structure is designed to withstand tail water levels equivalent to full spillway discharge at FSL. Access to the powerhouse is through a road cuts off from the spillway bridge.

1.4.7 Generating Equipment

The generating equipment will have a rated net head of 95m. At the rated unit discharge of 98.5 m^3/s, rated turbine output at an assumed full gate efficiency of 92.5% is 80.64 MW. The three turbines are conventional vertical axis Francis machine with steel scroll case and elbow draft tube. The runner diameter is 3.22 m and the distributor is set at El. 49 m, 3 m below nominal design tailwater level (TWL). The rotational speed is 214.3 rpm yielding a specific speed of 198.8.

With all 3 units operating at full gate and reservoir at FSL, net head is 112.3 m and maximum turbine output is 87.18 MW at 98.5 m^3/s, or 100.7 MW at 100 m^3/s with restricted gate opening. At 97.5% assumed efficiency and 0.85 power factor, corresponding generator outputs are 118.9 and 11505MVA, respectively.

Condition	Operation	Head (m)
Maximum	Full supply level (FSL) with one unit operating	114
Average	Average reservoir level (EI. 162m), 2 unit operating at average flow	106
Minimum	Minimum operating level (MOL) with all unit operating	81

1.4.8 Switchyard and Transmission Facilities

A 138 KV switchyard covering a rectangular area about 49.57m x 11.5m will be located at the upstream of the power house at a distance of about 150m. The proposed switching facilities on the high voltage side incorporate “one –and-a-half breaker” scheme with incoming circuits – one from each generator transformer and two outgoing transmission circuits employing six breakers. This will be connected to the existing Kibawe substation.

1.4.9 Access Road

The proposed road network will consist of access roads, service roads and temporary roads. The access road and service road will be 6.0m wide with the length of 15.3km. The access roads will be gravel surfaced roads, except for the 4km of service road to be concreted. The temporary roads consist of 6.0mx6.0km gravel surfaced road and 12.0m x10km gravel surfaced roads.

1.4.10 Waste Management System

During the construction phase of the project, the proponent and the contractor shall implement proper waste management. Installation of temporary Materials Recovery Facilities and compost pits may be provided during the construction phase of the project.

Waste storage facilities such as septic tanks or portable toilets may be installed on site during construction. The contractor should ensure that no untreated human wastes should be allowed to enter any water course where this will affect downstream water quality, aquatic environment, and human health. Change in aesthetic character of the area can be minimized by disposing of excavated materials as soon as possible to designated temporary dump sites. Likewise, the contractor must undergo proper clean up and abandonment of the site such as removal of temporary bunkhouses, stock yard and other unnecessary structures after completion of the construction activities.

Hazardous wastes from vehicles and heavy equipment such as leakage of fuel, oil and grease should be contained and handled properly. DENR Accredited third party disposal should oversee that all hazardous wastes (either solid or liquid) are primarily contained.

Sources of hazardous liquid wastes are the oil and grease from vehicles and heavy equipment. Periodic maintenance of these vehicles should be conducted in all phases of the Project to prevent leakage.

Hazardous waste such as waste oil, spent lubricants and solvents including contaminated materials resulting from leakage of oil and fuel should be collected and stored in designated containers. Areas designed for the storage of hazardous materials are to be clearly designated by HAZCHEM signage, and the storage of such materials outside these areas is strictly prohibited. All hazardous materials are to be transported by and disposed thru DENR Accredited third party service provider.

Areas designated for storage of hazardous liquids, fuel, oil and other chemicals shall have a compacted base and be surrounded by a bund to contain 110% of any spillage. Large fuel storage facilities (>5,000 L) shall be covered by a root to minimize the potential for infiltration and contamination of runoff. Alternatively, ventilated containers and individual spill pallets should be used, depending on the volume of hazardous materials. All fuel and lubricant storage sites shall drain into an oil and water separator. All oil and water separators are to be maintained after any rainfall event of >20 mm.

1.5 Process Technology

1.5.1 Dam Type

The weak foundations eliminate any type of conventional concrete dam including the use of roller compacted concrete (RCC). During the earliest study stages a concrete faced rockfill dam (CFRD) was adopted. As knowledge of geological condition improved, the design was progressively modified by incorporating flatter slopes to suit the weak foundations and poor quality fill material available locally. However, it was it was ultimately concluded that a CFRD is not appropriate for this site largely due to concern as to difficulty in establishing a satisfactory foundation for the base of the upstream face. Thus, the selected dam is a “Rock Fill” embankment with a central impervious core.

1.5.2 Hydraulic Turbine and Main Accessory Equipment

The gross water head of this project is in the scope of 61.5m～112.3m, and it was recommended to utilize 3 units of Francis turbine. The major parameters of turbine and accessory equipment are as follows:

Table 1-6: Description of Turbine

Parameter	Description
Basic Parameters of Hydraulic Turbine	
Turbine Model:	HL( )-LJ-340
Turbine Rated Output:	87.18MW
Rated Head:	95m
Rated Flow:	98.50 m3/s
Rated Speed:	225 r/min
Unit Speed under Rated Operation Condition:	78.48r/min
Unit Flow under Rated Operation Condition:	0.87m3/s
Efficiency at Rated Operation Condition Point:	94.2%
Max. Efficiency:	94.53%

Cavitation Coefficient:	0.078
Specific Speed:	224m·kW
Erection Level:	52.00m
Main Accessory Equipment of Hydraulic Turbine	
Governor WT-80-6.3	
Oil Pressure	6.3MPa
Oil Pressure Unit:	HYZ-2.5-6.3
Inlet Valve	DN4500mm PN2.5MPa
Powerhouse Crane	160+160/32/10t Lk=22m

1.5.3 Main Electrical Connection

The project will be equipped with 3 vertical mixed flow turbine generating sets with a single capacity of 85MW. The total installed capacity is 255MW, and the generator terminal voltage is 13.8kV. The 138kV voltage level is used to connect to the system network. The voltage side wiring of the generator is connected by one machine and one transformer unit, with a total of 138kV and 100MVA booster transformers.

Table 1-7: Description of Generating Unit

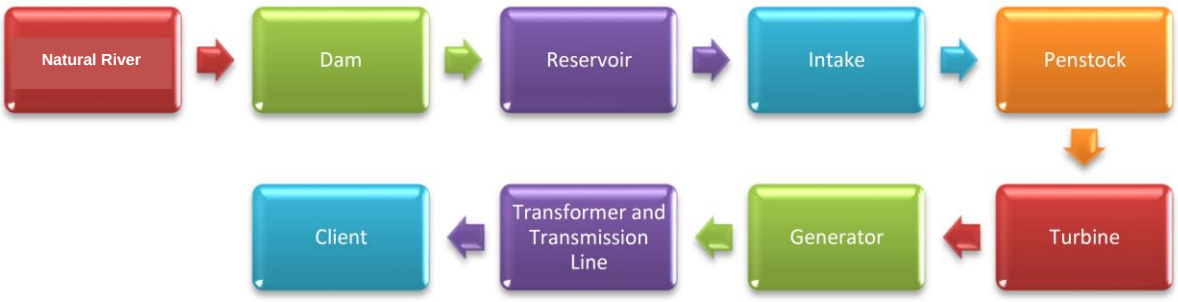
Parameter	Description
Parameters of Generator	
Model:	SF85-32/7650
Type:	Vertical, suspended
Rated capacity:	85 MW
Rated speed:	225 r/min
Rated voltage:	13.8kV
Rated frequency:	60 Hz
Rated current:	4183.8A
Rated power factor (lagging):	0.85
Insulation level:	F
Parameters of Main Transformer	
Type:	three-phase double-winding off-circuit tap-changing transformer (SF11)
Rated capacity:	100000kVA
Rated frequency:	60Hz
Voltage regulation mode:	off-load voltage regulation
Transformation ratio:	138±2×2.5%/13.8
Connection group:	YNd11

1.5.4 Power Generation

Hydropower plants capture the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy. In general, the power generation would follow the stages below:

- **First stage**: acquire water energy-pool the water and centralized waterhead.
- **Second stage**: adjust water energy-water energy and storage and adjustment.
- **Third stage**: divert water energy-divert the water to power house.
- **Fourth stage:** water energy conversion- convert water energy to mechanical energy and power energy.
- **Fifth stage:** transmission and distribution power energy -convert to power energy parameter, and transmit and distribute power energy to clients.

Generator efficiency is normally 97%~97.5%, and the turbine efficiency is normally 93%~94%.



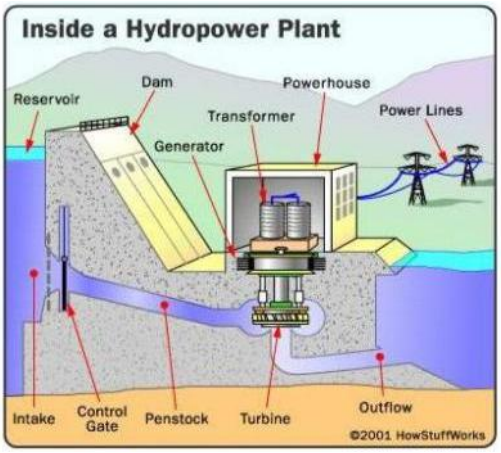


Figure 1-8: Hydropower Plant Generation

1.5.5 Waste Management

Environmental protection measures during construction period include the following measures:

1. Control measures against air pollution

The project may cause during construction air pollution such as dusts from excavation, filling and bulking, transportation, loading and unloading; waste gas from equipment and machinery operation; smokes from burning; emission from air conditioning and other cooling systems. In order to minimize the abovementioned pollution and harms, control measures may be taken in action:

a. Equipment and machinery in good quality will be purchased and operated, as well as full maintenance, to ensure fuel fully combusted for standard emission.
b. Watering may be needed for keeping moist to minimize the dust in excavation areas.
c. Transportation vehicles with sideboards will be covered by waterproof tarpaulin when transported in bulk.
d. All access roads at construction areas will be kept clean and watered to minimize the dusts when vehicles pass.
e. Disposal areas will be equipped with watering systems so as to minimize dust.Watering is also needed when it is windy and gusty.
f. Workmen will wear dustproof masks where dusts are more likely to be generated.

g. Dusts reducing system will be installed in areas where dust and smoke are more likely to be generated such as gravel crushing plants, sieving plants and cement filling plants.
h. Regular dust and powder investigation will be carried out to ensure standard emission is complied as per the laws and regulations of the Philippines Government.

2. Control measures against noise pollution

Noises maybe produced when there are borehole drillings, sand and gravel processing, air compressor operating, framework fabricating, explosive blasting, concrete batching and placing as well as other construction machinery operating and vehicles running. In order to minimize disturbance and hazard to local residents and workmen, control measures will be taken into action which includes the following:

a. Relatively fixed locations such as compressor room, framework fabrication plants, concrete batching plants and gravel processing plants will be located at a safe distance from residential areas. Noise insulating shelters will be installed to insulate noises from mixers, concrete pumps, electric saws and large compressors. If necessary, sound walls will be constructed where construction takes place near residential areas. Noise refresh rooms will be installed for workmen in these areas.
b. Mufflered or lower noised equipment and machinery will be used as much as possible.
c. Strict timing will be set when construction takes place nearby inhabitants, no later than 22:00pm and no earlier than 6:00am. Necessary negotiation with local people will be made where construction demands 24-hours shift. Control measures against noise will be carried out as per government laws and regulations.
d. When blasting, amicable communication with local residents is a must. Security will warn concerned stakeholders.
e. Daily exposure of work men will be controlled under the noise level not louder than 80 decibels. Workmen in noisy areas will wear ear plugs.

3. Control measures against water and soil pollution

Pollutants such as waste oil, waste water, solid waste, medical waste may be produced during the project construction. In order to minimize the pollution of surface water and underground water or to minimize the pollution of agricultural lands, control measures will be taken into action:

a. In areas where waste oils are more likely to be produce such as repair shops, air compressor rooms and oil depots, oil drums and storage tanks will be installed to collect the waste water. Well-designed sewage ditches will be built with sediment ponds to collect the waste oil flow in. Regular checks will be made either to recycle the waste oil or for proper disposal.
b. Special sinks will be installed to collect the kitchen grease. Cleaners will maintain the sinks regularly at the ends of drainage systems of the canteens.
c. Settling ponds will be installed where waste water are more likely to be produced in areas such as living camps, concrete batching plants and gravel washing. Waste water will be discharged after precipitation.
d. Toilets will be installed to meet health requirements. Dirt will be treated as per requests by the Employer.
e. Recycle stations will be installed for sorting the wastes into categories of recylclables and non-recylclables. The non-recylclables wastes will be diposed of or collected properly.
f. Medical wastes will be treated strictly as per local laws and regulations. The medical officer will monitor as the wastes are treated. Unauthorized incineration and burial are prohibited.

g. Lands taken up by temporary roads and buildings can be restored and recovered free from contamination. Top soil will be taken away and will be stored as per requirements. Top soil restoration will be done after completion.

4. Control measures against soil erosion and rainstorm

Site activities may impact the topography of areas where excavation, tunneling, road construction and muck disposals take place. Rainstorms may cause further soil erosion. Drainage ditches will be built properly and reasonably to ensure rainstorms will not flood. The ditches also work to protect the nearby farmlands, waterways and inhabitant buildings, etc.

5. Control measures for muck disposal areas

a. Top soil will be taken away before the muck disposal areas are put into use. The soil will be sorted for storage and will be documented so as to restore the area after completion.
b. During muck disposal, it is required to compact in layers so as to achieve stability of layers.
c. The support to slops and layers' feet will be made and drainages will be set up as well.
d. Hill and stockpiling spoil shall be provided around the site drainage system, settling ponds, silt curtains. Set in the block below it washed down the ridge to collect fines from the mountains of spoil material and cleaned regularly. Muck disposal areas will be set up with drainages, sediment ponds and silt curtains. At the bottom of muck disposal areas blockades will be set up to collect wash-downs; the blockades will be cleaned regularly.

Other activities will also ensure that:

a. Natural topsoil will be collected and stored for restoration after completion.
b. Rare plants will be removed to other locations and will be moved back after completion.
c. Ensure the stability of the slope, to prevent slumping.
d. Spoil mountain shape after the completion should be integrated with the local topography, surface spoil mountain trimmed to match the shape of the local terrain.
e. Reasonable drainages will be set up so as to discharge the internal leaking as well as to keep from losing fine-grained materials. Surface water will be diverted from disposal areas so as to keep from flooding the rainstorms.
f. Retaining walls will be set up where disposal areas are close to rivers.

6. Control measure against wastes

a. Solid wastes commonly seen in construction sites include construction dregs including bricks, tiles, macadam, residuals, concrete fragments, iron and steel scraps, glass cullet, refuses, waste decoration materials; wasted bulk building materials; domestic garbage including cooking and kitchen wastes, abandoned foods, waste paper, living appliances, glass, potsherds, waste batteries, wasted daily necessities, plastic wastes, fly ash, wasted traffic means; packing materials of equipment and materials; and night soils.

b. Treatment and disposal of solid wastes

i. Recycling: Reclaim the materials having recyclable value, for example, reinforcement bars.
ii. Reduction processing: Reduction processing refers to sorting, crushing, compaction, thickening, and dewatering to reduce the final processing amount and the treatment cost as well as pollution to the environment.

iii. Landfill. This refers to disposal that the solid wastes have been subjected to hazard free treatment, reduction treatment before transporting to the landfill site for disposal. Landfill of noxious and harmful wastes on the site is strictly banned. Landfill site will utilize natural or artificial barriers to isolate the wastes to be disposed from the environment as possible. In addition, stability and long-term safety of wastes will be paid attention to.

iv. Natural degradation: Degradable solid pollutants, for example, night soil, spoiled foods, can be degraded in a centralized way and utilized as fertilizer.

7. Control measures against hazardous materials

A management plan will be composed for hazardous materials, hazardous materials storage, use, handling and other activities for safety management, to avoid leaks, causing environmental damage.

8. Traffic Management

To ensure that construction traffic does not affect the public safety, the SQE section intends to take the following measures to control:

a. To make up a full set of traffic safety regulation and arrange drivers' training.
b. Drivers must be qualified before running the vehicles.
c. All the construction vehicles must be locally registered.
d. Set up a bulletin board in a public road at both ends of the construction area, suggesting that local public transport vehicles, personnel considerations. Under special circumstances, will send staff to direct traffic to divert the flow of traffic and to give priority to local public transport.
e. Construction vehicles must strictly comply with local traffic laws, driving guidelines.
f. Make sure the vehicles are properly covered so as to avoid what is loaded from scattering.

9. The protection of paleontological and archaeological sites

If unknown paleontological and archaeological sites are found, the construction work will stop immediately in order to avoid interference or destruction of these sites and instantly notify the Employer's representative, who will communicate with the local government departments. The construction will continue after approval.

10. Construction areas restoration and recovery

After completion of the project, there will be recovery measures on influenced area, mainly in area of construction facility deployment area, construction living camp, temporary access road and quarry yard, earth ditch, etc.

1.6 Project Size

The power component of the project consists of three (3) units, each having rated output of 83.33 MW at 100 m^3/s or a total capacity of 250 MW at 300 m^3/s. At normal storage level, the reservoir will have a gross volume of 1,169.3 x 10^6 m^3. The area of the reservoir will be 2,924 ha encompassing the Municipalities of Damulog, Dangcagan, Kibawe and Kitaotao. The powerhouse, associated facilities and equipment will occupy an area of approcimately 5 hectares.

1.7 Development Plan, Description of Project Phases and Corresponding Timeframes

1.7.1 Pre-Construction Phase

All necessary permits and clearances will be secured from concerned government agencies before the start of any construction activities. The Pre-construction Phase includes selection and awarding of contracts to contractors for the construction of the dam, spillway, diversion facilities, power facilities and other auxiliary/ support facilities. It also includes land acquisition for the location of the hydropower plant, auxiliary facilities and reservoir vis-à-vis the relocation/resettlement of the affected families.

1.7.2 Construction/ Development Phase

The use of explosives for the excavation of construction materials will be minimal due to soft weak rocks in the source area. Road headers, a form of low cost tunneling machine, will be used for tunnel excavation.

The construction schedule will have duration of 65 months from awarding of the construction contract to commissioning of the two (2) generating units **(Table 1-8).**

Table 1-8: Schedule of Construction Activities

Activity	Duration (months)	Cumulative Duration (months)
1. Main construction contract award	-	-
2. Mobilization of initial facilities at site	4	4
3. Construction of river diversion facilities	19	23
4. River diversion and cofferdams	3	26
5. Preparation of dam foundations, riverbed area	4	30
6. Construction of dam embankment	27	57
7. Closure of the second diversion tunnel	-	57
8. Reservoir filling	2	59
9. Testing and commissioning of Unit #1	3	63
10. Testing and commissioning of Unit #2	3	65

1.7.3 Operation Phase

This phase refers to the commercial operation of the Hydropower Plant for an estimated plant life of 50 years, which may be extended, depending on the future condition of the plant. The plant will operate year round, for a 24-hour period, subject to scheduled preventive repair and maintenance of the power plant facilities and its support facilities to ensure its smooth operation within the projected lifespan. Activities include receiving of water from the dam going to the penstock, water distribution to the 3 generating units via the trifurcation, electric power generation by the power plant, delivery of electricity through the transmission lines, use of waste management and support facilities, and support facilities, and preventive maintenance works.

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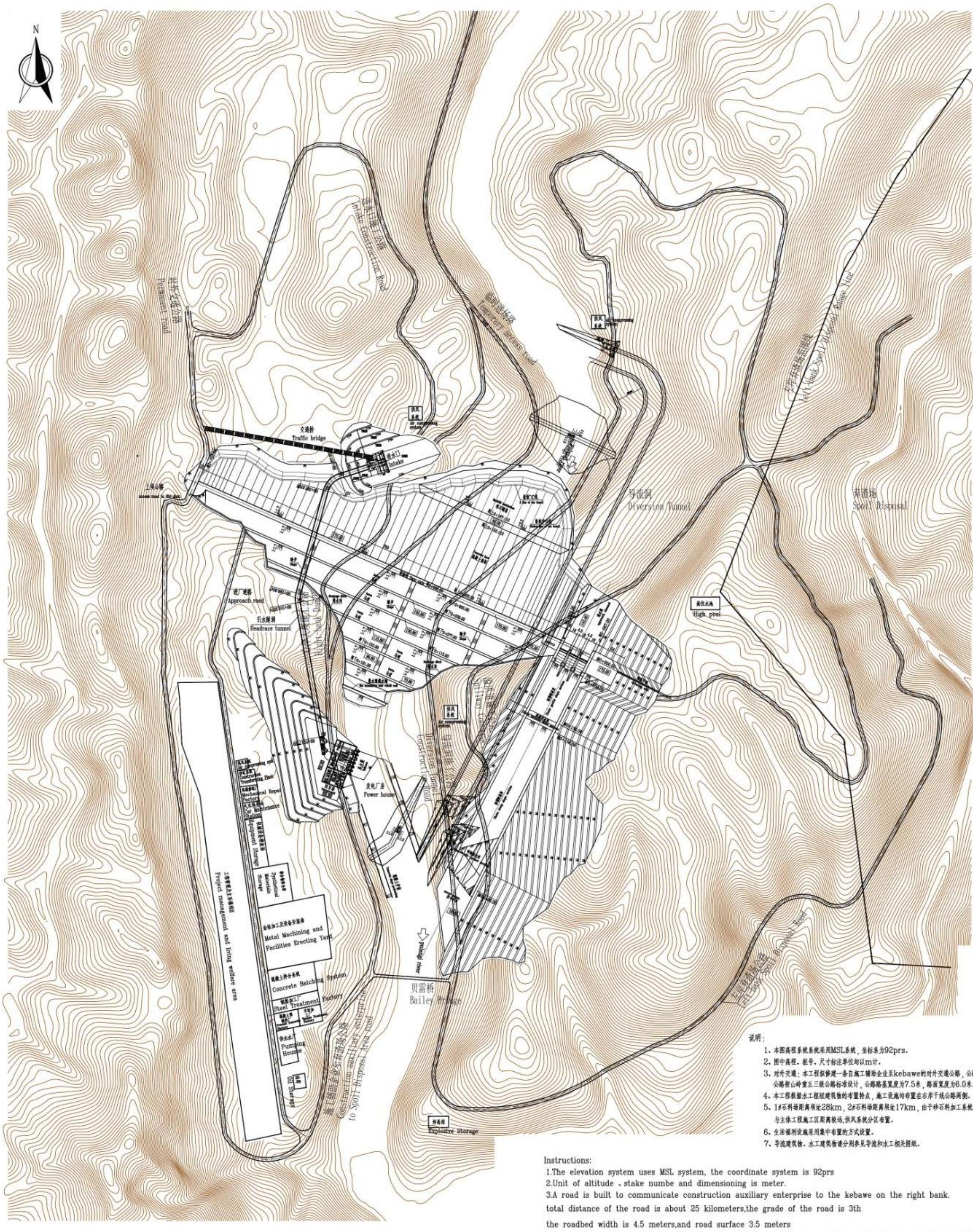
South-pulangi水电站施工总布置图
South-pulangi hydropower station construction general layout

1:1000



说明：

1、本图高程系统系统采用MSL系统，坐标系为92prs。
2、图中高程、桩号、尺寸标注单位均以m计。
3、对外交通：本工程拟修建一条自施工辅助企业至kebawe的对外交通公路，公路总长约25km，公路按山岭重丘三级公路标准设计，公路路基宽度为7.5米，路面宽度为6.0米。
4、本工程根据水工程组建筑物的布置特点，施工设施均布置在右岸干线公路两侧。
5、1#石料场距离坝址28km，2#石料场距离坝址17km，由于砂石料加工系统布置于2#石料场与主体工程施工区距离较远，供风系统分区布置。
6、生活福利设施采用集中布置的方式设置。
7、导流建筑物、水工建筑物请分别参见导流和水工相关图纸。

Instructions:

1.The elevation system uses MSL system, the coordinate system is 92prs
2.Unit of altitude . stake numbe and dimensioning is meter.
3.A road is built to communicate construction auxiliary enterprise to the kebawe on the right bank. total distance of the road is about 25 kilometers,the grade of the road is 3th the roadbed width is 4.5 meters,and road surface 3.5 meters
4.According to the arrangement characteristic of hydraulic structure of the project,the construction facilities are arranged on both sides of the outside transportation road of the right bank.
5.1# rock quarry is 27km far from dam site,2# rock quarry is 17km far from dam site. As the sandrock processing system located in 2# rock quarry,far away from the construction area of main project So air compressing system are arranged dispersively.
6.Living and welfare facilities are arranged dispersively, one living and welfare districts are built
7.Diversion buildings and hydraulic structures can be seen in the related graphs of diversion and structure

主要施工公路特性表

序号	名称	设计标准	路基宽度(m)	路面宽度(m)	公路里程(km)	备注
一	[illegible]					
1	[illegible]	[illegible]	7.5	6.0	25.0	[illegible]
2	[illegible]		7.5	6.0	4.0	[illegible]
二	[illegible]					
1	[illegible]		9.0	7.0	2.0	[illegible]
2	[illegible]		9.0	7.0	3.5	[illegible]
3	[illegible]		9.0	7.0	1.2	[illegible]
4	[illegible]		9.0	7.0	3.0	[illegible]
5	[illegible]		9.0	7.0	1.3	[illegible]
6	[illegible]		9.0	7.0	1.8	[illegible]

Main Features of Construction Roads

S/N	Name	Design Standard	Roadbed Width(m)	Road Surface Width(m)	Road Mileage(km)	Remarks
一	Outgoing Road					
1	Permanent road	Mountain Ridge [illegible]	7.5	6.0	25.0	Rock Ballast Pavement
2	Temporary road		7.5	6.0	4.0	Rock Ballast Pavement
二	Internal Construction Road					
1	Left-bank Spoil Disposal Road		9.0	7.0	2.0	Rock Ballast Pavement
2	Diversion Tunnel Construction Road		9.0	7.0	3.5	Rock Ballast Pavement
3	Right-bank Dam Construction Road		9.0	7.0	1.2	Rock Ballast Pavement
4	Spillway Construction Road		9.0	7.0	3.0	Rock Ballast Pavement
5	Intake Construction Road		9.0	7.0	1.3	Rock Ballast Pavement
6	Construction auxiliary enterprise to Spoil Disposal Area road		9.0	7.0	1.8	Rock Ballast Pavement

SOUTH PULANGI 水电站主要施工设施一览表

序号	项目	设计规模	建筑面积 (m²)	占地面积 (m²)	备注	序号	项目	设计规模	建筑面积 (m²)	占地面积 (m²)	备注
1	[illegible]	220t/h	1000	50000	[illegible]	12	[illegible]		2000	5000	
2	[illegible]	150m³/h	500	5000		13	[illegible]	40t	400	800	
3	[illegible]	600m³/min	300	1000		14	[illegible]		200	600	
4	[illegible]	3000m³/h	300	2000		15	[illegible]			3000	
5	[illegible]	5000kvA	300	1000		16	[illegible]	2250人	25000	60000	
6	[illegible]	12t/班	400	2000		17	[illegible]			700000	
7	[illegible]	14m³/班	400	1500		18	[illegible]			400000	
8	[illegible]	12m³/d	300	1500		19	[illegible]	25km		700000	
9	[illegible]	37.5万工时/年	300	1000		20	[illegible]	12.8km		192000	
10	[illegible]		1200	15000			合计		32900	2142400	
11	[illegible]	[illegible]	300	1000							

Construction and Floor Space of Main Facilities

No	Item	Design scale	construction area(m²)	Floor Area (m²)	Remarks	No	Item	Design scale	construction area(m²)	Floor Area (m²)	Remarks
1	sandstone processing system	220t/h	1000	50000	located in 2# rock quarry	12	Synthetical Materials Storage		2000	5000	
2	Concrete Batching System	150m³/h	500	5000		13	Explosive Storage	40t	400	800	
3	Air compressing system	600m³/min	300	1000		14	Oil Storage		200	600	
4	Pumping House	3000m³/h	300	2000		15	Equipment Storage			3000	
5	Construction Transforming Plant	5500kvA	300	1000		16	Living Welfare Area	2250人	25000	60000	
6	Steel Treatment Factory	12t/班	400	2000		17	Left-bank Spoil Disposal Area in Dam Site			700000	
7	Timber Treatment Factory	14m³/班	400	1500		18	Quarry			400000	
8	Precast Concrete Factory	12m³/d	300	1500		19	Access Road	25km		700000	
9	Mechanical Repair Factory	37.5万工时/年	300	1000		20	Road Net	12.8km		192000	
10	Metal Machining and Facilities Erecting Yard		1200	15000			Total		32900	2142400	
11	Car Maintenance Station	[illegible]	300	1000							

CHINA ENERGY ENGINEERING CORPORATION LIMITED

South Pulangi Hydropower station Project		Hydraulic Structure SECTION	Feasibility Study DESIGN
APPROVED	李山峰	Construction General Layout	
VERIFIED	李山峰		
EXAMINED	熊永斌		
CHECKED	李艺		
DESIGNED	唐川		
2017.11.5	SCALE 1:1000	DRAWING No.	45380K-143-001

Lichel Technologies, Inc.
1403 Prestige Tower Condominium,
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE:

General Construction Layout

FIGURE NO.

1-9

During the normal operation, the 3 turbine units will be in operation with aggregate discharge of 300 m^3/s or 285 MW nominal plant capacity. The relatively uniform regime, specifically the absence of very high flow periods, means that very little energy is lost due to spill. At a maximum inflow is wasted. At this capacity, during periods of substantial reservoir drawdown when generating firm energy, the plant will operate at relatively high monthly capacity factors in the range of 55% to 70%.

1.8 Abandonment Phase

Although there is no plan to abandon the project after its projected lifespan of 50 years, abandonment will require the demolition of the constructed facilities, and clean-up of the area to restore it as close as possible to its original condition unless there is an intention to renovate the facilities to expand its operational lifespan. Further considerations for abandonment/decommissioning of the project are discussed in **Section 8** of the report.

1.9 Manpower Requirements

The manpower requirement during construction, consisting of contractors and subcontractors, is estimated to be about 1500 up to a maximum of 2,250 during the peak of construction. There will be a Project Management Team (PMT) consisting of about 120-150 personnel. During operation, the manpower requirement is 90 personnel to be distributed in the three (3) main departments of management, operation, and maintenance. **Table 1-9** shows the indicative manpower requirements for the Project. **Table 1-10** shows the indicative breakdown of the expertise/skill needed during the different project phases. Skills need in terms of expertise includes operators of heavy equipmwnt, dirvers, welders, surveyors, managers and engineers. As the project moves from pre-construction to construction phase, there will be more workers needed fror the manual labor component. From construction phase to operations phase of the project, there will be lesser need for manal labor and manpower requirements would focus on managerial, operations and maintenance personnel. **Table 1-11** shows the indicative breakdown of available jobs for men, women and for Indigenous People.During the preconstruction phase there will be 1000 jobs available to men, 200 for women and 400 for the IPs. During the construction phase, 1200 jobs will be available for men, 300 for women, and 600 for IPs. It should be noted that these figures are indicative in nature and may change based on actual ground conditions and based on agreements with the LGUS and IPs. PHPC will develop a hiring scheme with the concerned local government units and people's organization to ensure prioritization of local residents during project implementation. This could be done through the Barangay officials or by organizing local cooperatives for this purpose.

Table 1-9: Indicative Manpower Requirements

Project Phase	Type	Number of Personnel
Pre-construction	Construction personnel	450-1,200
	Project Management	60-120
Construction Phase	Construction personnel	1200-1,400
	Project Management	120-150
Operations Phase	Operations personnel	50

Table 1-10: Indicative Breakdown by Expertise/Skill

No.	Project Phase Type	Pre-construction	Construction Phase	Operations Phase
1	Operator of Mixing Station	10	10	/
2	Operator of Aggregate Processing System	20	25	/

No.	Project Phase Type	Pre-construction	Construction Phase	Operations Phase
3	Air Compressor Operator	10	15	/
4	Driller	40	50	/
5	Blaster	20	20	/
6	Heavy Machinery Operator	120	150	/
7	Driver	150	200	/
8	Form Fixer	60	80	/
9	Steel Bar Worker	80	80	/
10	Concreter	80	80	/
11	Welder	30	40	/
12	Drilling and Grouting Worker	40	60	/
13	Electrician	10	10	4
14	Generator Operator	5	10	/
15	Lifting Worker	10	15	/
16	Metal Structure Worker	10	40	/
17	Bench Worker	5	10	/
18	Pumping Worker	10	10	/
19	Surveyor	15	15	/
20	Repair Man	15	15	6
21	Bricklayer	10	25	/
22	Decorator	10	25	/
23	Backman	320	400	30
24	Project Management Personnel and Engineer	120	150	10
25	Total	1200	1535	50

Table 1-11: Indicative Distribution of Jobs

No.	Type	Pre-construction	Construction Phase	Operations Phase
1	Men	1000	1200	40
2	Women	200	300	10
3	IPs	400	600	30

1.10 Project Cost

The indicative cost of the project is US $ 699,666,000.00 or Php 37,369,161,060.00 (as of Aug 14, 2018 exchange rate of Php 53.41).

1.11 Project Schedule

The indicative project schedule is shown in **Table 1-12**. The first year would entail the preparation period that includes the securing of the necessary permits and approvals. This woud also include the tendering of contracts for the construction activities. Construction would commence on the second year up to the fifth year. Commissioning is expected on the 1st quarter of year 6 with full operation expectd on the 2nd quarter of year 6.

Table 1-12: Indicative Project Schedule

Activity	Y1				Y2				Y3				Y4				Y5				Y6			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Permit and Clearances Acquisition/ Preparation Period																								
Construction/Civil Works																								

Activity	Y1				Y2				Y3				Y4				Y5				Y6			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Commissioning																								
Operations																								

2 ANALYSIS OF KEY ENVIRONMENTAL IMPACTS

2.1 Land

2.1.1 Land Use and Classification

2.1.1.1 Compatibility with Existing Land Use

Seven (7) landuse/vegetation types/units were identified, described and mapped within the project area. The landuse/vegetation types/units are: Annual crops (Corn/Sugarcane); Coconut with Corn/Sugarcane; Tree Plantation; Built-up area; Grassland; Shrubland and Forest (**Figure 2-1**).

Annual crops are the dominant landuse in the project area from south to north. Corn is the dominant crop. Sugarcane is also being planted particularly in the northern part, west side of the Pulangi River bank.

Coconut with Corn/Sugarcane exists in the northern part of the project area, west side of the Pulangi River bank. A unit also exists in the southern part in the Municipality of Kibawe. Coconut with Corn/Sugarcane is the areas with low density Coconut plantations with either Corn and/or Sugarcane as intercropped.

Tree Plantations exist in patches all over the project area. Tree species planted are Acacia Manguim, Acacia Auricuformis, Mahogany, Eucalyptus, etc. Mango tree plantation exists in the middle part of the project area at Barangay Tinaciacan, Kibawe.

Built-up areas are the residential areas/ Barangay proper.

Grassland exists in the southern part of the project area near the proposed sites of the dam and powerhouse. Also grassland exists in the northern part of the project area. Grass species are Cogon and Talahib.

Shrubland exists in the southern part of the project area. Shrub species are of the pioneering type- Trema, Binunga, Bamboo, Ficus/Balete, etc.

Forest exists in the very steep slopes of the Pulangi River banks in the north. Also units exist in the very steep slopes in the southern part, right side and middle part in the Municipality of Kibawe. Forest species are some remnant of dipterocarps, Narra, Molave, Mahogany, Falcata, Bamboo and etc.

In the dam site and reservoir areas, there will be actual change of land use. A total of 2,878 ha will be inundated which are mostly agricultural and forestland. To mitigate this, inventory of the affected vegetation should be conducted prior to construction/site preparation. Appropriate compensation should be provided to affected landowners, owners of crops and trees and owners of other improvements. Provisions of relevant laws should serve as basis for the compensation of affected lots, crops and other improvements.

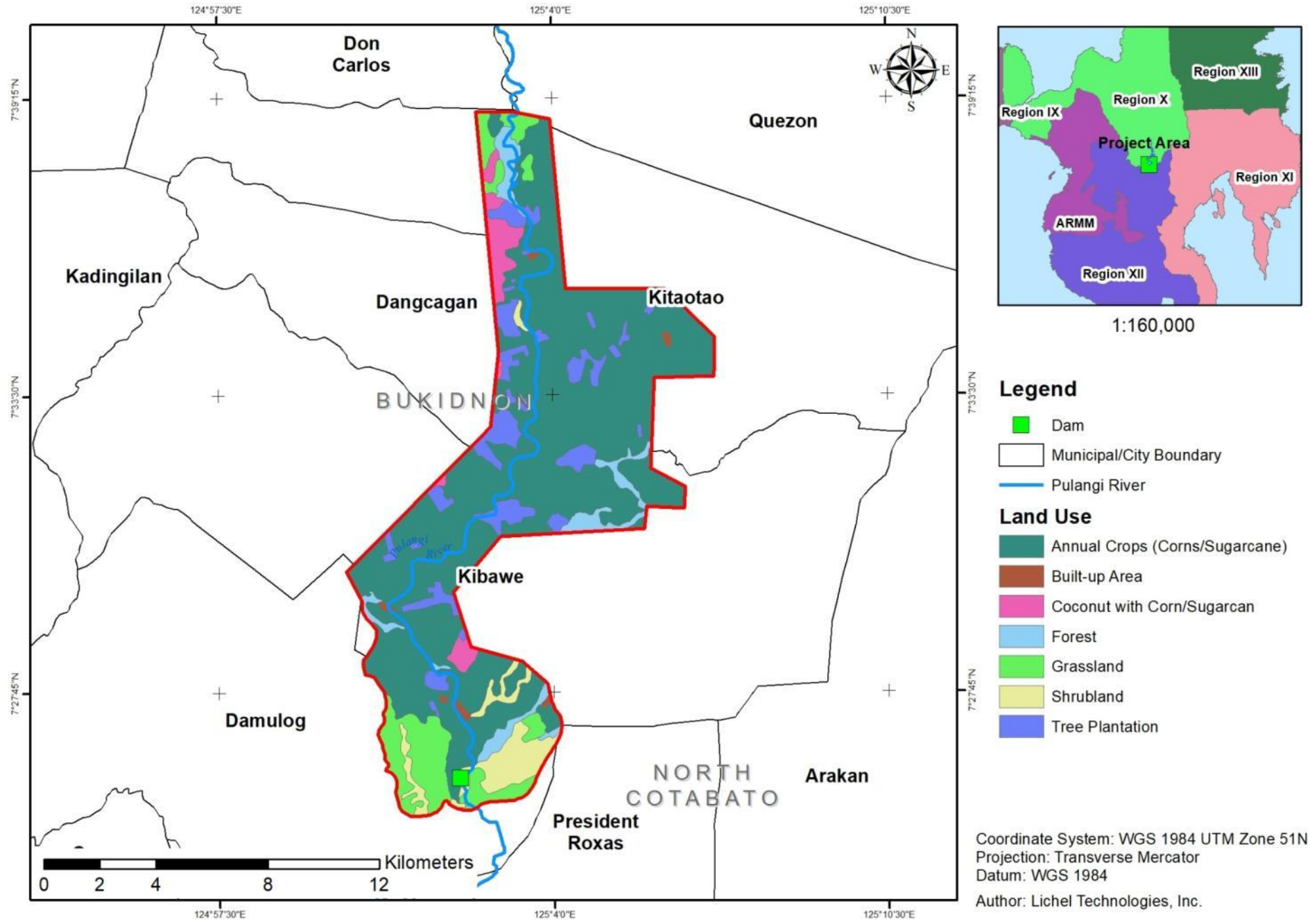


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FIGURE TITLE :

Land Use/Vegetation Map

FIGURE NO.:

2-1

2.1.1.2 Compatibility with Classification as an Environmentally Critical Area

The Project is located within Environmentally Critical Areas (ECAs) as defined by Presidential Proclamation 2146 and further clarified in Section 3.b of EMB Memorandum Circular 005 Series of 2014 "Technical Definition of ECA and Corresponding Operationalization Guide of the Revised Guidelines for Coverage and Screening and Standardized Requirements under the Philippines EIS System". The Memorandum Circular states that an area is environmentally critical if it exhibits any of characteristics described in the 12 categories that define environmentally critical areas. **Table 2-1** shows a brief description of the ECA categories and the site characteristics that qualifies the project area under each category.

Table 2-1: Criteria for Environmentally Critical Areas

ECA Categories	Technical Definition (EMB MC 2014-05)	Project Site Characteristics
Areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries	Areas declared under RA 7586 (NIPAS Act) Areas declared by other NGAs, LGUs, International commitments and declarations	Not Present Nearest declared Waterhsed Forest Reserve is 30km from project site (Muleta WFR)
Areas set aside as aesthetic, potential tourist spots	Aesthetic potential tourist spot declared by the LGU, DOT or other appropriate authorities for tourism development. Class 1 and 2 Caves	Not Present Land use map of the LGU does not identify any potential tourism area within the Project Site.
Areas which constitute the habitat for any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	Areas identified as Key Biodiversity Areas or local conservation areas	Not Present
Areas of unique historic, archaeological, geological, or scientific interests	Areas declared as historic sites, Barangay or municipality of cultural or scientific significance to the nation Barangay or municipality where archaeological, paleontological, and anthropological sites/reservations are located	Present The area is within an Ancestral Domain/ Ancestral Lands
Areas which are traditionally occupied by cultural communities or tribes	Areas issued with CADT or CALT Areas that are historically/traditionally occupied as ancestral lands or ancestral domains of indigenous communities	Present The area is within a declared Ancestral Domain/Ancestral Lands
Areas frequently visited and/or hard-hit by natural calamities.	Geologic hazards Area	Present The project area is categorized as moderately to highly susceptible to landslide based on the MGB Landslide Hazard Susceptibility Map
	Areas Frequently visited by typhoons	Present The proposed project site belongs to a zone wherein one (1) tropical cyclone occurs in every year.
	Areas prone to volcanic activities/earthquakes	Not Present
Areas with critical slope	Areas with slope of 50% or more	Present
Areas classified as prime agricultural lands	Lands that can be used for various or specific agricultural activities and can provide optimum	Not Present

ECA Categories	Technical Definition (EMB MC 2014-05)	Project Site Characteristics
	sustainable yield with a minimum of inputs and development costs	
Recharge areas of Aquifers	Sources of water replenishment where rain water or seepage actually enters the aquifers. Areas under this classification shall be limited to all local or Non-national watersheds and geothermal reservations.	Present
Water bodies	All natural water bodies (e.g. rivers, lake, bay) that have been classified or not	Present Project Area is within Pulangi River.
Mangrove areas		Not Present
Coral reefs		Not applicable

2.1.1.3 Existing Land Tenure Issues

Indigenous settlements within the directly affected inundated area should be resettled at proper locations, taking into account their preferences, resettlement land area, and hazardous risks. Those affected by the inundation should be properly compensated as to prevent social unrest and hostile tendencies. Based on records from the NCIP, there is currently no Certificate of Ancestral Domain Title in the Project Area. Nonetheless, the Proponent is currently applying for the Free, Prior and Informed Consent (FPIC) process as stipulated in NCIP AO 03-2012 to eventually secure their Certification Precondition (CP) prior to the start of the project. In addition, the preparation of a Land Acquisition and Resettlement Plan and the Indigenous People Action Plan should include the possible actions that need to be taken to address the loss of land for the affected communities.

2.1.1.4 Impairment of Visual Aesthetics

Visual changes will mostly be apparent during the construction of the dam and power station. During the construction of the dam and power station, disturbances brought about by clearing, grubbing and earth moving activities will reduce visual quality of the land. However, after 3 years of construction, disturbed, open and barren areas will have vegetation regrowth and some will be replanted. Vegetation growth will bring back the aesthetic value of the land. The dam should blend in with the surrounding environment after construction phase.

2.1.1.5 Devaluation of Land Value

The Project is not expected to decrease land value. Proper solid waste management shall be observed during the construction phase of the Project. Contractors will also be required to observe proper waste management and orient their respective workers on the same.

Summary of Impact Assessment and Mitigation for Land Use and Classification

The summary of impacts associated to land use and classification with the corresponding mitigation measures are presented in **Table 2-2.**

The impact of the project on the land use/vegetation of the project area of the proposed Dam and Powerhouse sites is nil as the vegetation clearing and excavation works will be concentrated on these sites. For farms that will be inundated, the farmers will be properly compensated. Trees and Shrubs that will be inundated will be mitigated through compensatory plantings on the upper slopes of the Pulangi River banks. Mitigating measures and management were discussed above.

Table 2-2: Summary of the Significant Impacts and Mitigation Measures for Land Use and Land Use Change

Potential Impact	P	C	O	A	Prevention, Mitigation and Enhancement Measures
Change/Inconsistency in land use		√	√		Impact on land use/vegetation is nil as disturbance/clearing of vegetation and excavation will just be concentrated on Dam and powerhouse sites. Vegetation clearing will be kept to a minimum and what is essential. Preferential scheduling of vegetation clearing and excavation works during the drier months (November to April of the following year). The agricultural fields/ tree plantations that will be inundated by the reservoirs, the Farmers will be properly compensated. The shrubs/trees that will be inundated will be mitigated through compensatory plantings on the adjacent upper slopes of the river banks.
Encroachment in Environmentally Critical Area		√	√		Impact in the environmentally critical area is nil as disturbance/clearing of vegetation and excavation will just be concentrated on Dam and powerhouse sites. Vegetation clearing will be kept to a minimum and what is essential. Preferential scheduling of vegetation clearing and excavation works during the drier months (Nov. to April of the following year). For the area to be inundated by the reservoir that is covered by the ancestral domain, prior right will be worked out with the IP group through the NCIP.
Possible CARP-related issues	√	√			If CARP exist in the Project area, meetings with DAR officials will be made to explain to the land owners that the project will not have an impact in their farms, except the farms that will be inundated, which will be compensated.

P=Pre-construction Phase; C=construction Phase; O=Operation Phase; A=Abandonment Phase

2.1.2 Geology/ Geomorphology

2.1.2.1 Scope

This section presents the information on the baseline assessment of the geologic and geomorphic characteristics including the natural geologic hazards (or geohazards) that prevails over the project area.

The site preparation before the construction of the project facilities may have impacts on the topography and its attendant geomorphological processes e.g. changes in the transport of sediments, river bank erosion, etc. Knowledge of the subsurface engineering properties of the rock mass at the proposed dam site is essential to determine if the bedrock is suitable for dam foundations. Lastly, the relevant natural geohazards and its potential risk to the project are identified, and the corresponding mitigation measures applied or recommended is also presented.

The scope of this section also responds to the recommendations outlined by the Mines and Geosciences Bureau Regional Office No. X (MGB RO-X) letter addressed to LTI on August 29, 2018 regarding the geohazard susceptibility of the proposed project. A copy of the letter is presented in **Annex 3.**

2.1.2.2 Methodology

The secondary information on geology, geomorphology and geohazards in the project sites and vicinities were sourced from government agencies, namely:

- Mines and Geosciences Bureau (MGB);
- Philippine Institute of Volcanology and Seismology (PHIVOLCS);
- Bureau of Soils and Water Management (BSWM); and
- National Mapping and Resource Information Authority (NAMRIA)
- University of the Philippines Nationwide Operational Assessment of Hazards (UP-NOAH)

A site visit was undertaken on September 4-6, 2018 to validate/supplement the available information. Other sources of information include published and unpublished reports of individuals as well as from the internet listed under the references. The integration of the various information follows the relevant sections prescribed in the MGB Memorandum Circular (MC) 2003-33 regarding the Guidelines and for the Preparation of an Engineering Geological and Geohazard Assessment Report (EGGAR).

2.1.2.3 Change in Surface Landform/ Geomorphology/ Topography/ Terrain/ Slope

Notable changes in terrain will occur from the construction of the dam and the power house. Earth materials needed for the dam embankments and other components will be excavated and moved from borrow area resulting to changes of the surface ground.

Changes in surface configuration are unavoidable and, thus, are permanent impacts. Unstable surfaces or slopes will require appropriate stabilization measures to prevent mass movement. Induced landslides are discussed further in **Section 2.1.2.5.**

2.1.2.3.1 Baseline Geomorphology and Topography

The BSWM consolidated geomorphological map classified the major landforms adjacent to Pulangi River from the proposed dam site to the reservoir areas as colluvial and alluvial terraces, and sedimentary hills (**Figure 2-2**). Colluvial and alluvial terraces dominate the northwest portion of Pulangi River in the municipalities of Kibawe, Dangcagan and Kitatao. These areas possess a terrain that vary from gently sloping to undulating and rolling. The eastern and southern areas including the municipality of Damulog are classified as sedimentary (shale/sandstone and limestone) hills of low to high relief. Changes in relief are often marked by abrupt changes in elevation forming small cliffs of uplifted horizontally layered rocks with different resistances to weathering and erosion (**Figure 2-3**). The banks of Pulangi River have moderate to very steep slopes forming narrow gorges in some sections.

Land elevation is generally between 200 to 300 meters above sea level (masl), except along Pulangi River where elevation descends to about 80 masl at the proposed dam site. Land aspect is towards the east.

2.1.2.4 Change in Sub-Surface Geology/ Underground Conditions

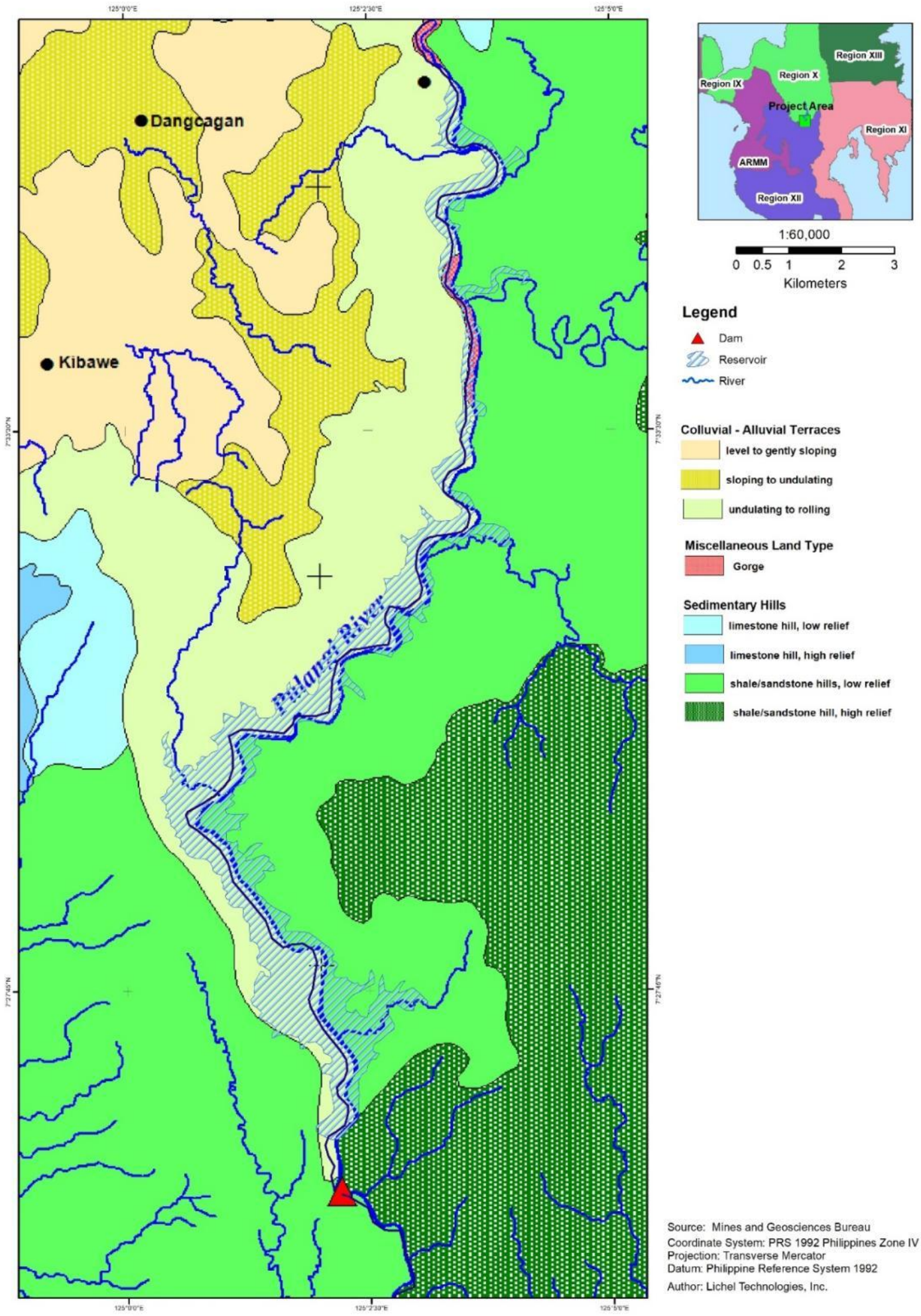
The construction and operation of Project components will not change the sub-surface geology of the project area. There is however a potential change in underground conditions resulting from weight imposed by the filling of large reservoir. Changes in stress on fractures or increased groundwater pore pressure that decreases the effective strength of the rock under the reservoir could result to Reservoir Triggered Seismicity (RTS). This is further discussed in **Section 4.1.**

2.1.2.4.1 Baseline Geologic Environment

Regional Tectonic Setting

The Central Mindanao terrane, the region of interest, is one of six blocks of the Philippine Mobile Belt in Mindanao Island (Rangin and Publlier, 1990 in Wikipedia). The Mindanao Island is bounded by the Philippine Trench on the east, the Sulu Trench on the west, and the Cotabato Trench on the southwest. The Philippine Trench is the morphological expression of the westward subduction of the Philippine Sea Plate under the eastern Philippine Arc (Hamburger et al. 1983, Cardwell et al., 1980, and Fitch 1970; in MGB, 2010). The Sulu Trench is locus of subduction of the Miocene Sulu Sea back-arc basin while the Cotabato Trench is linked to the subduction of the Eocene Celebes Sea basin (Rangin and Silver 1991 in Sajona et al. 1997).

Associated with these subduction zones are arc systems. However, whereas the Sulu-Zamboanga Arc and the Cotabato Arc are related to the Sulu Trench and Cotabato Trench respectively, the active volcanic chain that includes Mount Apo and other volcanic cones in central Mindanao are more than 100 km away from any active subduction zone. Sajona (1995) as cited in MGB 2010) proposed that the active volcanic chain was not produced by subduction but are products of partial melting of a detached slab underneath Mindanao.



Source: Mines and Geosciences Bureau
Coordinate System: PRS 1992 Philippines Zone IV
Projection: Transverse Mercator
Datum: Philippine Reference System 1992
Author: Lichel Technologies, Inc.

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FIGURE TITLE:

Geomorphological Map

FIGURE NO.

2-2

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FIGURE TITLE:

Terrain Map

FIGURE NO.

2-3

In addition to the active trenches, the major active structures in Mindanao include the Philippine Fault (southern segment) and the Mindanao Fault. The sinistral Philippine Fault (alternatively termed as the Philippine Fault Zone) in eastern Mindanao strikes NNW-SSE and consists of several segments that runs from Surigao City to Mati, Davao Oriental. The left-lateral Mindanao Fault is a northwest-trending linear structure that runs from Sarangani Province to the northwest of Zamboanga Peninsula. The fault consists of two segments: the Cotabato Fault and the Sindangan Fault. The Cotabato Fault separates the Daguma Range from the Cotabato Basin while the Sindangan Fault represents the northwestern extension of the Mindanao Fault. **Figure 2-4** presents the active faults and trenches in Mindanao.

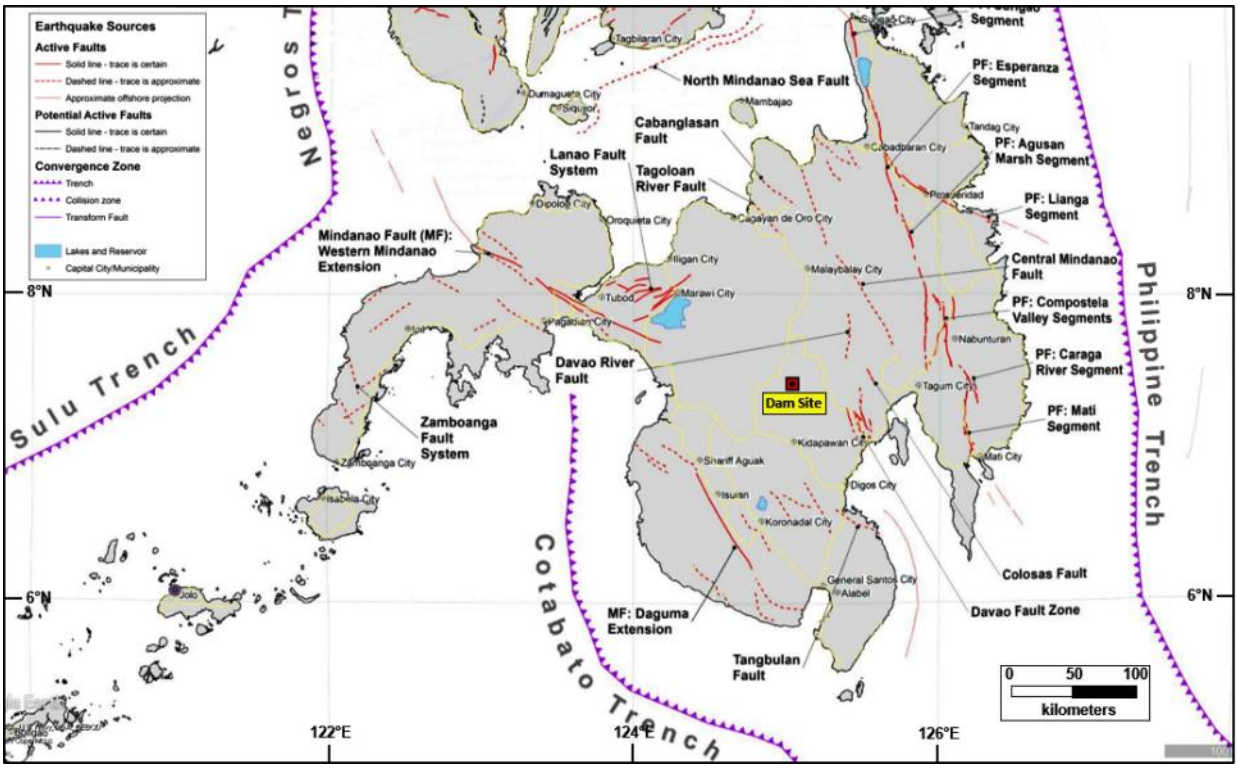


Figure 2-4: Active Faults and Trenches in Mindanao

(Source: PHIVOLCS)

Regional Seismicity

The United States Geological Survey - National Earthquake Information Center (USGS-NEIC) maintains a catalog of historical earthquakes from various worldwide sources. A search of from the catalog within 200-km radius of the proposed dam yielded 196 seismic events of greater than M 5.5 from February 1918 to present (**Figure 2-5**). The distribution of the range of earthquake magnitudes is shown in **Table 2-3**. The recent M 7.0 earthquake on December 29, 2018 has epicenter approximately 255 km southeast of the proposed dam site (**Figure 2-5**).

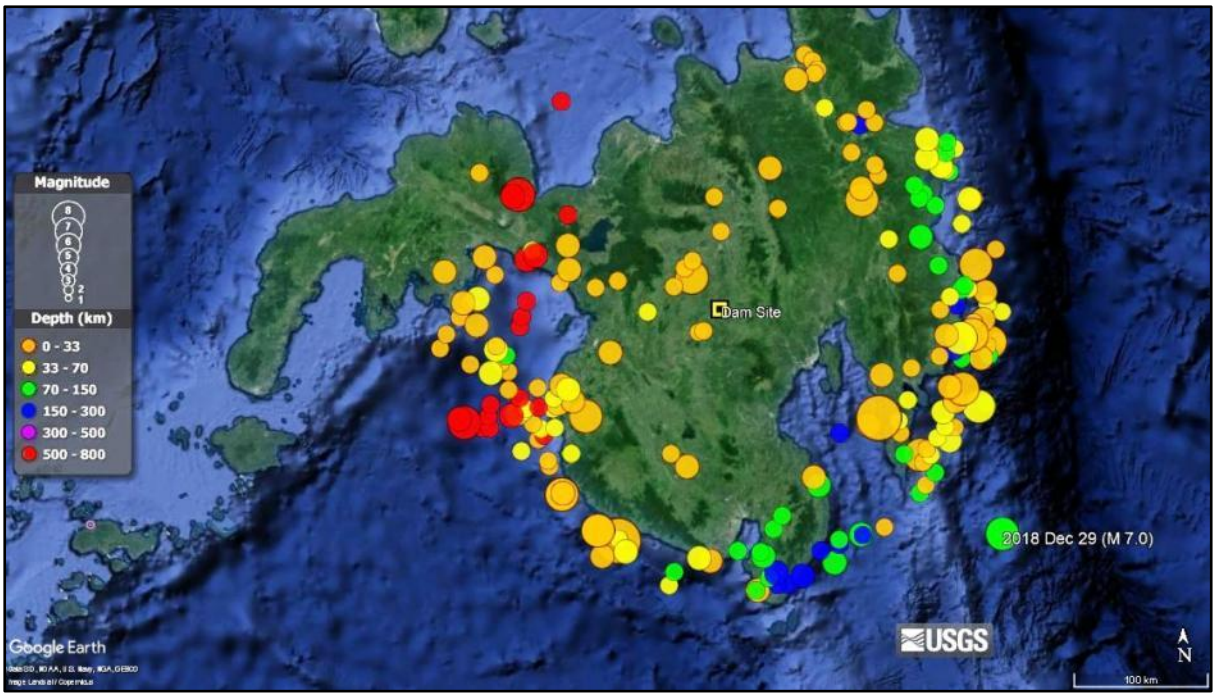


Figure 2-5: Seismicity Map (200-km radius from the Dam Site)

(Source: USGS-NEIC)

Table 2-3: Distribution of Earthquakes from 1918 to Present within 200-km of the Dam Site

Magnitude (M)	Number of Events	Percentage
8.0 to 8.3	2	1.0
7.0 to 7.9	14	7.1
6.0 to 6.9	54	27.6
5.5 to 5.9	126	64.3
Total	**196**	**100.0**

A series of earthquakes, the strongest at M 5.4, shook the Bukidnon-Lanao del Sur area on September 24, 2017[1]. Reportedly, the earthquake originated to a newly discovered fault line in Wao, Lanao del Sur[2]. The epicenter is located approximately 35 km northwest of the proposed dam site.

Figure 2-6 is a zonal earthquake occurrence rate (N/year) for Mw ≥ 5.2 derived by PHIVOLCS (2017). The x-axis shows the individual seismic source zone while the y-axis indicates the frequency or number of earthquake events per year. Seismic source zones identified for the project region are the Cotabato Trench, Mindanao Fault (Daguma Extension), Davao River Fault and the Philippine Fault (Agusan Marsh fault segment). Among the four seismic sources, the Cotabato Trench is the most seismically active source zone at 0.5 events per year while the Mindanao Fault, Davao River Fault and the Agusan Marsh Fault have occurrence rates of about 0.1 events per year.

[1] NEIC earthquake catalog indicated a M 5.9 at coordinates 7.562°N 124.743°E and depth of 8.18 km.
[2] SunStar Philippines, September 25, 2017. New 'fault line' discovered as quake jolts some parts of Mindanao. Retrieved from https://www.sunstar.com.ph/article/165899, January 9, 2019.

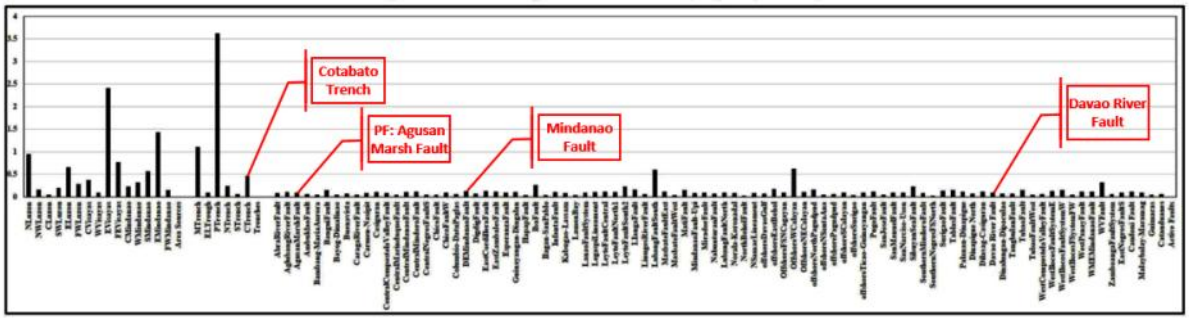


Figure 2-6: Zonal Earthquake Occurrence Rate, N/year (Mw ≥ 5.2)

(Source: PHIVOLCS, 2017)

Figure 2-7 is a plot of the destructive earthquakes of Mindanao Island from 1885 to the present. The Moro Gulf earthquake of August 17, 1976 at M 7.9 was the worst natural calamity to hit Mindanao in terms of casualties and damage to properties 9 (Mangao et al., 1994). The offshore event, caused by the movement along the Cotabato trench, generated 20-foot tsunamis that inundated the coastal areas of Southern Mindanao.

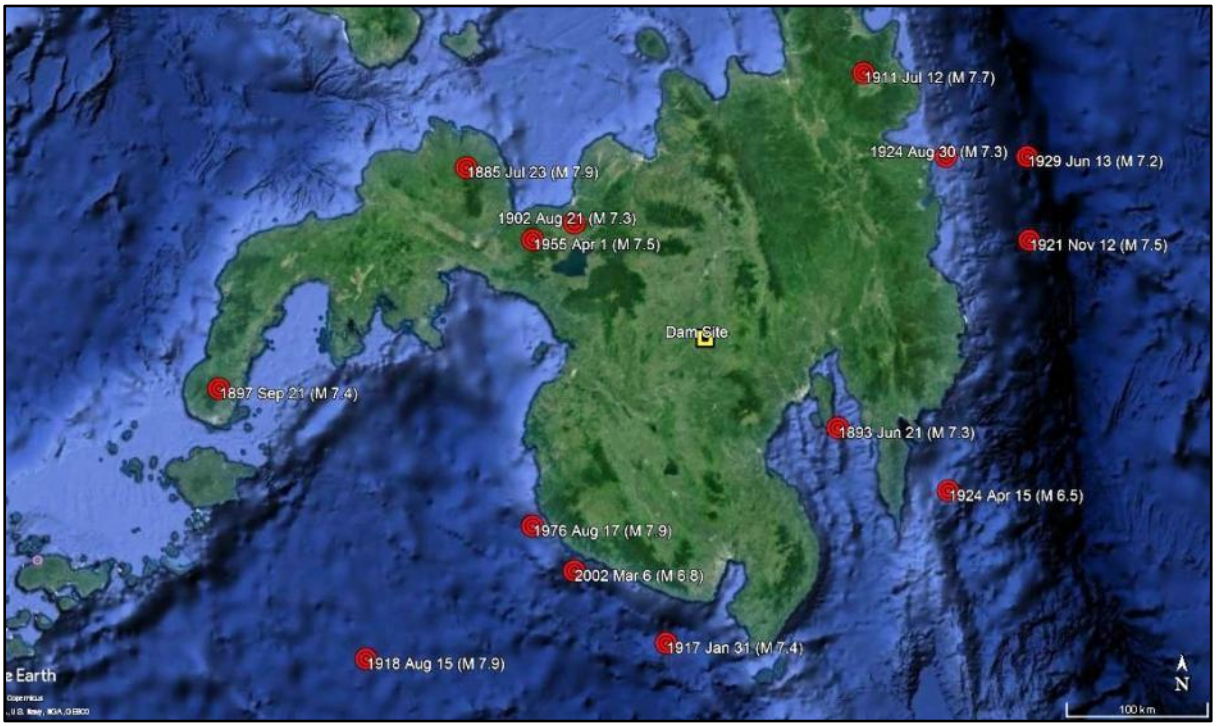


Figure 2-7: Destructive Earthquakes in Mindanao Island

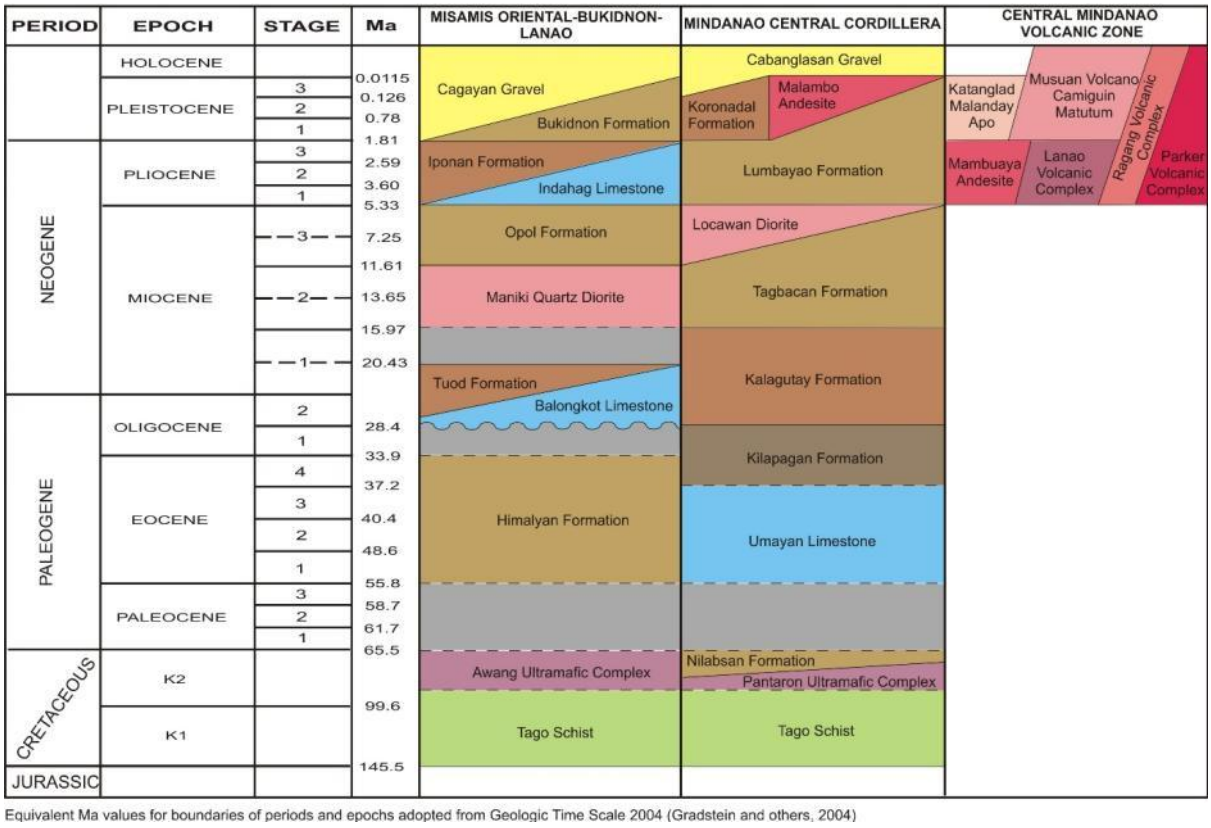
(Source: SEASEE, 1985; Mangao et al., 1994)

General Geology and Stratigraphy

The following discussions were taken from the MGB Second Edition of the Geology of the Philippines (2010).

The MGB delineated the Philippine archipelago into distinct stratigraphic groups. The project is situated in the Central Mindanao stratigraphic group (SG-22) that is subdivided into Misamis Oriental-

Bukindon-Lanao, Mindanao Central Cordillera and Central Mindanao Volcanic Complex. The stratigraphic column of Central Mindanao is shown below.



Equivalent Ma values for boundaries of periods and epochs adopted from Geologic Time Scale 2004 (Gradstein and others, 2004)

Figure 2-8: Stratigraphic Column of Central Mindanao

(Source: MGB, Geology of the Philippines, 2010)

The Misamis Oriental-Bukidnon-Lanao-Bukidnon basement rocks consists of pre-Tertiary ultramafic complex and undifferentiated metasediments and metavolcanics overlain by Late Oligocene to Early Miocene limestones, clastic sedimentary rocks, volcanic flows and volcanic breccias. In southwestern Misamis Oriental, the metasediments, metavolcanics and limestone are intruded by Middle Miocene quartz diorite stocks and andesitic dikes. Late Miocene clastic sediments overlie the older formations.

The Mindanao Central Cordillera occupies the eastern portion of Central Mindanao and borders the west side of the Agusan-Davao Basin. This sub-stratigraphic group basically follows a similar sequence consisting of Pre-Cretaceous basement ultramafic and metamorphic rocks and Late Cretaceous (?) pyroclastic rocks and mudstones. The basement rocks are unconformably overlain by a series of Paleogene and Neogene clastic sedimentary rocks. A Late Miocene igneous composite of diorite with pyroxenite and gabbro (Locawan Diorite) intrudes the Late Oligocene-Early Miocene sedimentary sequence (Kalatugay Formation).

The Misamis Oriental-Bukidnon- Lanao and the Mindanao Central Cordillera is blanketed by the Central Mindanao Volcanic Complex consisting of volcanic deposits from eruptions of Quaternary volcanic centers defined by a belt from Camiguin Island in the north to Mt. Parker in the South.

Geology of the Project Area

Figure 2-9 shows the project area superimposed on the Geological Map of Bukidnon of the MGB RO-X. The project, at the dam site and along the submerged section of Pulangi River, is underlain by Pliocene-Pleistocene marine and terrestrial sediments, and by Late Miocene-Pliocene marine and fluviatile facies, and volcanic deposits.

The Pliocene-Pleistocene sediments composed of conglomerate with limestone pebbles, sandstone, mudstone and limestone, interpreted here as belonging to the Lumbayao Formation based on the MGB stratigraphy of 2010. This formation underlies the dam site and most of Pulangi River at Damulog municipality. Northwards in the municipalities of Kibawe, Dangcagan and Kitatao, the Pulangi River cuts across Late Miocene-Pliocene sediments and pyroclastics. These older sediments also composed of mudstones, sandstones, conglomerate and limestone, and is interpreted here as the Kalagutay Formation. However, the MGB dated the Kalatugay Formation as Late Oligocene-Miocene which is unconformably overlain by the Lumbayao Formation. The pyroclastic equivalent composed of andesitic volcanic breccia, tuff breccia, lapilli tuff, ash tuff and agglomerates which was previously designated as Malayanan Formation by Santiago (1983) as cited in MGB 2010.

The sedimentary rocks long the Pulangi riverbanks are gently- to moderately inclined. Younger sedimentary formations exposed as cliffs are essentially horizontal beds. Photographs of rock exposures are shown in **Annex 4.**

Hydrogeology

In the published MGB Groundwater Availability Map of the Philippines, the sedimentary units in the project area are classified as local and less productive aquifers of very low to moderate permeability. Well yields are mostly about 2 liters per second (lps) but as high as 20 lps in some sites.

In the Water Data Bank of the Local Water Utilities Administration (LWUA), 41 groundwater users were listed in the four municipalities of Damulog, Kibawe, Dangcagan and Kitaotao, about half (21) of the which are in Kibawe. Most of the water wells have depths between 20 to 50 meters. Only a few exceeds 100 meters. No well yields were however reported.

2.1.2.5 Inducement of Subsidence, Liquefaction, Landslides, Mud/Debris Flow

The Philippines, because of its geographic and geologic location, is vulnerable to natural hazards. These hazards must be considered and integrated in the project development plans.

Geologic and geomorphic conditions in the Project area indicate that the proposed hydroelectric power plant project is vulnerable to seismic, mass movement and hydrological hazards.

The assessment of natural hazards and assiociated risk is detailed in **Section 4.1** of the report.

2.1.2.6 Summary of Potential Geohazards and Recommended Mitigative Measures

Table 2-4 is a summary matrix of the potential hazards, its risks, causes and impacts on the proposed development, and the corresponding mitigations recommended to manage the potential impact.

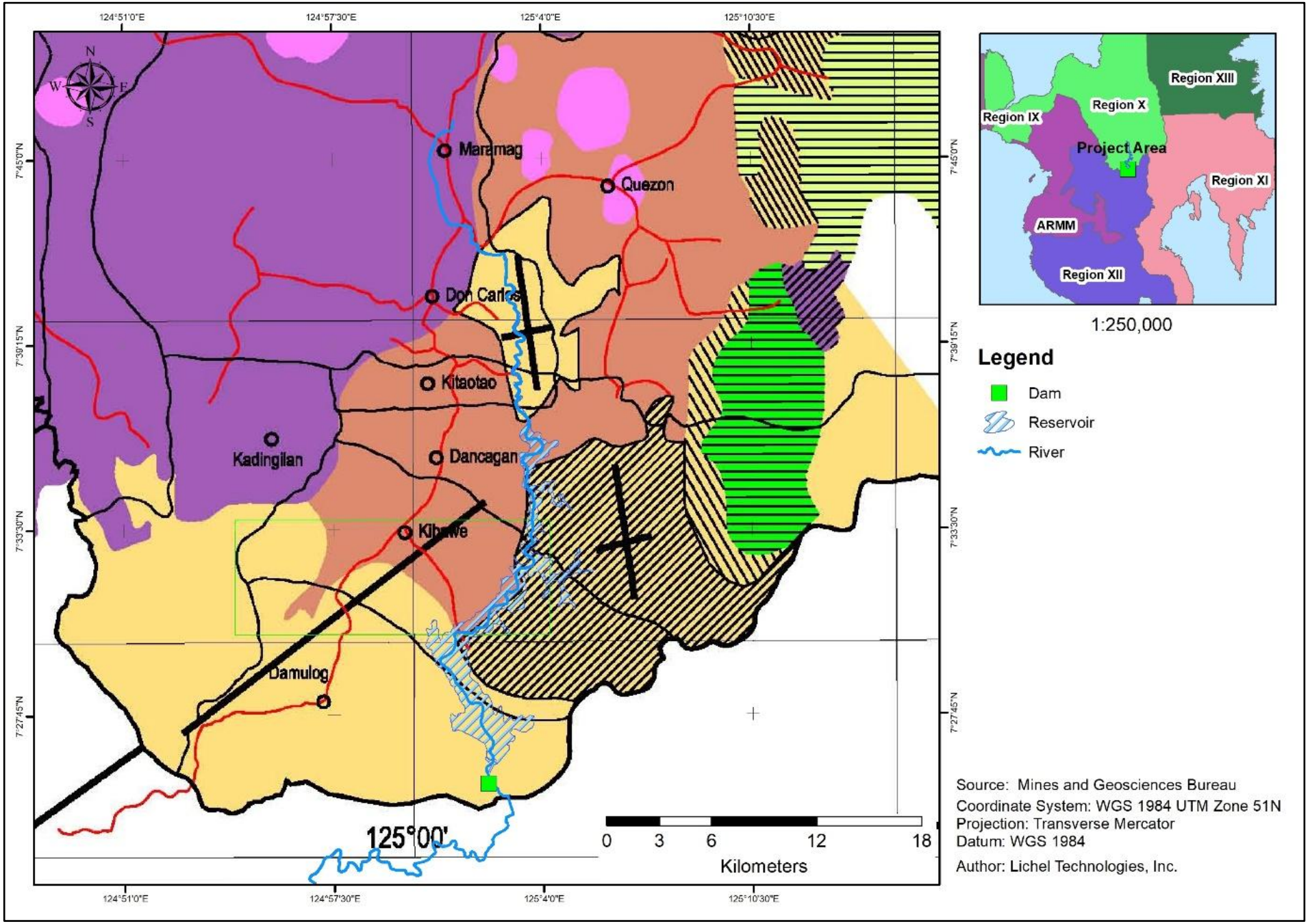


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FIGURE TITLE :

Geological Map of the Project Area

FIGURE NO.:

2-9

Table 2-4: Summary of the Significant Impacts and Mitigation Measures for Geohazards

Geohazard	Potential Risk	Causative Factors	Impact	Mitigations Applied/Recommended
Seismic Hazards				
Ground acceleration (intense ground shaking)	High	Earthquake	Structural failures: Foundation defects, including settlement and slope instability, internal erosion.	Site specific ground conditions and PGA should be given attention in the final design of the infrastructures and facilities. Seismic loading analysis should consider the Maximum Credible Earthquake (MCE) and the Operational Basis Earthquake (OBE). The proposed structures should also adhere to design guidelines of local and international design standards. Engineering measures to mitigate slope failures in subsurface excavations should be applied to reduce impact of seismic event. Monitoring instruments should be installed to verify the assumptions and conditions considered for the foundation and facility design. Visual inspection of the infrastructure and facilities after major earthquakes; minor damage to structure should be repaired immediately.
Ground Rupture	Low	Earthquake	Structure deformation (cracking of structure)	Although the project facilities are far from known active faults, the proponent should consider conducting a seismic imaging of the dam site and immediate in the vicinities to identify major possible structures/discontinuities not evident during the surface mapping. Geologic mapping during the excavation to map unrecognized and undetected structures during

Geohazard	Potential Risk	Causative Factors	Impact	Mitigations Applied/Recommended
				the surface mapping due to limitation of exposure brought about by inaccessibility of the outcrop, and rocks concealed by vegetation and weathered profile/zone. Modification of engineering design should be considered as the need arises brought about by the changes in the nature and geotechnical properties of lithology as they are uncovered during the excavation. Visual inspection of the infrastructures after major earthquakes; minor damage to structure should be repaired immediately.
Liquefaction and liquefaction-induced lateral spreading	Low	Earthquake	Settlement, structure deformation	Although liquefaction is unlikely to occur at the project site; this does not preclude the proponent to conduct liquefaction potential assessment of the site since the project will build critical structures. Visual inspection of the infrastructure and facilities after major earthquakes; minor damage to structure should be repaired immediately.
Seiche	High	Earthquake	Overtopping, instability of dam upstream face	Sufficient freeboard of the dam; concrete slab will be constructed on the upstream face of the dam for protection.
Mass Movement Hazards				
Landslide	High on dam site; high to moderate adjacent to the reservoir (submerged)	Earthquake; heavy prolonged rainfall weathering of steep slopes of weak materials; Deforestation; cut and fill	Rapid burial of structures Generating seiche within the reservoir Mass movements blocking rivers and forming landslide dams and lakes whose	Grading of road side-cuts to stable slope conditions, re-vegetation, and emplacement of slope stabilization and retaining structures. The retaining structure may consist of gabion or a grouted riprap to avoid embankment failure.

Geohazard	Potential Risk	Causative Factors	Impact	Mitigations Applied/Recommended
	areas	of steep slopes	failure may lead to overtopping of run-of-river power plants or the inundation of powerhouses with equipment, and damage downstream	Alternatively, benching of the slopes may also be appropriate. Properly designed drainage; direct measure is by sealing cracks and fissures with asphalt or soil cement. Identify areas that are prone to massive mass movement and adopt appropriate mitigating measures to minimize this impact.
Volcanic Hazards				
Volcanic ashfall (2mm size particle)	Low	Explosive volcanic eruption with prevailing winds	Collapse of roofs, smothering of vegetation, and physical damage to equipment.	Low impact given the remoteness to active volcanoes; nearest active volcano (Musuan) located some 50 km to the north. Immediate washing of accumulated ashes on roofs. Equipment should be covered when there is an impending ash fall, and the ash should be removed before normal operations.
Hydrologic Hazards				
Flooding – inundation and flashfloods	Very high on active channel; high on low level grounds adjacent to active channel	Heavy prolonged rainfall,	Inundation of low level areas; overtopping of dams .	Relocation of communities living in areas to be submerged by the reservoir; Adequately-designed dam to handle most probable floods (sufficient freeboard height, spillways)
Erosion and siltation	High to	Normal erosion cycle; extreme during flood	Reduced reservoir capacity	Adequate dead storage capacity of the dam was allotted for sediments.

Geohazard	Potential Risk	Causative Factors	Impact	Mitigations Applied/Recommended
(sediment and debris)	moderate	events		Identify areas in the entire dam catchment that are prone to massive erosion and adopt appropriate mitigating measures such as slope stabilization and erosion control measures to minimize this impact. This can be accomplished by formulating and implementing an effective Erosion and Sediment Control Program (ESCP)/ Watershed Management in partnership with concerned stakeholders.
Risks associated with dams and appurtenant structures				
Overtopping, surface embankment erosion, piping and seepage	Low to medium	Surface and internal erosion of the foundation or embankment	Potential hydraulic failure of dam	Properly and adequately designed dam and appurtenant structures Construction of the dam should strictly follow design specifications
Reservoir Triggered Seismicity (RTS)	Low to medium	Reservoir filling; water-level changes or during operation of the reservoir	Structural instability; fault displacement in reservoir bottom; Water waves in reservoir or loss of freeboard	The earthquake magnitudes reported by most of the RTS cases were small, being M 5.5 or less. Only a few suspected cases experienced a triggered earthquake of greater than M 6. Reservoir triggered ground motion should in no case be greater than the MCE ground motion and the faults considered capable of triggering seismicity should be taken into consideration during the seismic hazard evaluation. For large dams located in seismically active regions, it is justifiable to install a microseismic network and to monitor the seismicity prior to, during and after impounding.

Geohazard	Potential Risk	Causative Factors	Impact	Mitigations Applied/Recommended
Settlement	Medium on dam foundations; high on rockfill embankment dam	Stress (loads) imposed on foundations Differences in geotechnical properties embankment materials (densification of soil and rockfill)	Structural failure, distortion	For settlement, recommendations on seismic loading analysis as presented above should be performed. Construction of the dam embankment strictly follows the design specifications. A Quality Control Plan should be developed to perform quality control testing of the compaction of embankment material.

2.1.3 Soil/Pedology

2.1.3.1 Soil Erosion/ Loss of Overburden

2.1.3.1.1 Methodology

The study on soils and land use covered the review of existing literature and maps of the project area. This was followed by a fieldwork last May 16 to 18, 2018.

Soil study was made in the representative sites of the soil mapping units of the soil types within the project area (Area of Interest), where soil samples were taken. Site selection was made with the use of the project location map and the NAMRIA topographic map with a 1:50,000 scale. Geographical position of each observation/sampling location was recorded using a GPS. Slope quantification was done with the use of topographic map with scale of 1:50,000 to determine the slope ranges/classes.

Soil samples were analyzed for Chemical properties (pH, N, OM, P and K), and heavy metals (Arsenic, Cadmium, Lead and Mercury, Copper, Zinc, Manganese, Iron and Chromium Hexavalent). Analysis was done in Mach Union Laboratory.

Existing land uses and vegetation units were identified, described and represented on a map. The identification of the different vegetation/land uses was done with the aid of google earth imagery interpretation.

Qualitative Suitability Classification was made by comparing the plant environmental requirements with the physico-chemical properties of the soils.

Soil erosion susceptibility or erosion potential of the project area was mapped using the soil mapping units. For each soil unit, erosion susceptibility was assessed based on a contributing factor taken at a time. The individual susceptibility assessments were then aggregated to form a composite erosion susceptibility score for the soil unit. The contributing factors include rainfall, soil erodibility, vegetation or landuse and slope.

They were characterized as follows:

- For the rainfall data as compiled in Malaybalay, Bukidnon Synoptic Station was used.
- Erodibility of the various soil mapping units was determined following the results of the field assessment and physical analysis.
- Vegetation or land use was assessed in the field. This was supplemented by the interpretation of google earth imageries.
- The slopes of the soil mapping units.

Impact management plan of the proposed Dam and Powerhouse were given.

2.1.3.1.2 Soils of the Project Area

Three (3) soil types with eleven (11) soil mapping units were identified, characterized and mapped in the project area. The soil types are the Kidapawan clay loam, Macolod clay and Faraon clay, which are subdivided into eleven (11) soil mapping units based on slope range differences. The soil mapping units are: Kidapawan clay loam, 3-8% slopes; Kidapawan clay loam, 8-18% slopes; Kidapawan clay loam, 18-30% slopes; Kidapawan clay loam, 30-50% slopes; Kidapawan clay loam, >50% slopes; Macolod clay, 8-18% slopes; Macolod clay, 18-30% slopes; Macolod clay, 30-50% slopes; Macolod clay, >50% slopes; Faraon clay, 18-30% slopes; and Faraon clay, 30-50% slopes (**Figure 2-10**). The locations of soil observation sites are plotted on the Soil Map, while the geographic coordinates are shown in **Table 2-5.**

Table 2-5: Soil Observation Location and Coordinates

Soil Observation	Location	Coordinates
1	San Vicente, Dangcagan	N 7°34' 16.96" E 125°2'44.22"
2	Tangkulan, Damulog	N 7° 25'30.87" E 125° 2'26.83"
3	Tangkulan, Damulog	N 7° 25'47.94" E 125° 2' 15.10"

Kidapawan clay loam and Macolod clay developed from the weathering of volcanic materials/ rocks, while Faraon clay developed from the weathering of limestone rocks.

Kidapawan clay loam, 3-8% slopes occurs in the volcanic plateau that extend to the river bank of Pulangi River on the western side at Barangays Kugan/Dolorosa and San Vicente, Dangcagan, and Barangay Kitaihon, Kitaotao. Other unit occurs at Barangay Kitubo, Kitaotao.

Kidapawan clay loam, 8-18% slopes occurs in the middle part of the project area in both sides of the river bank of Pulangi River. Two (2) units also occur in the northern part, west side of Pulangi River bank.

Kidapawan clay loam, 18-30% slopes occurs in the middle part of the project area both sides of Pulangi River banks.

Kidapawan clay loam, 30-50% slopes occurs in the middle part of the project area both sides of the Pulangi River banks at Barangay Natulongan, Kibawe.

Kidapawan clay loam, >50% slopes occurs on the very steep slopes of the Pulangi River banks in the middle and northern parts of the project area.

Macolod clay, 8-18% slopes occurs in the southern part of the project area both sides of the Pulangi River banks, in Damulog Municipality.

Macolod clay, 18-30% slopes occurs in the southern part of the project area both sides of the Pulangi River banks, and at the middle part, eastern side in the Municipality of Kitaotao.

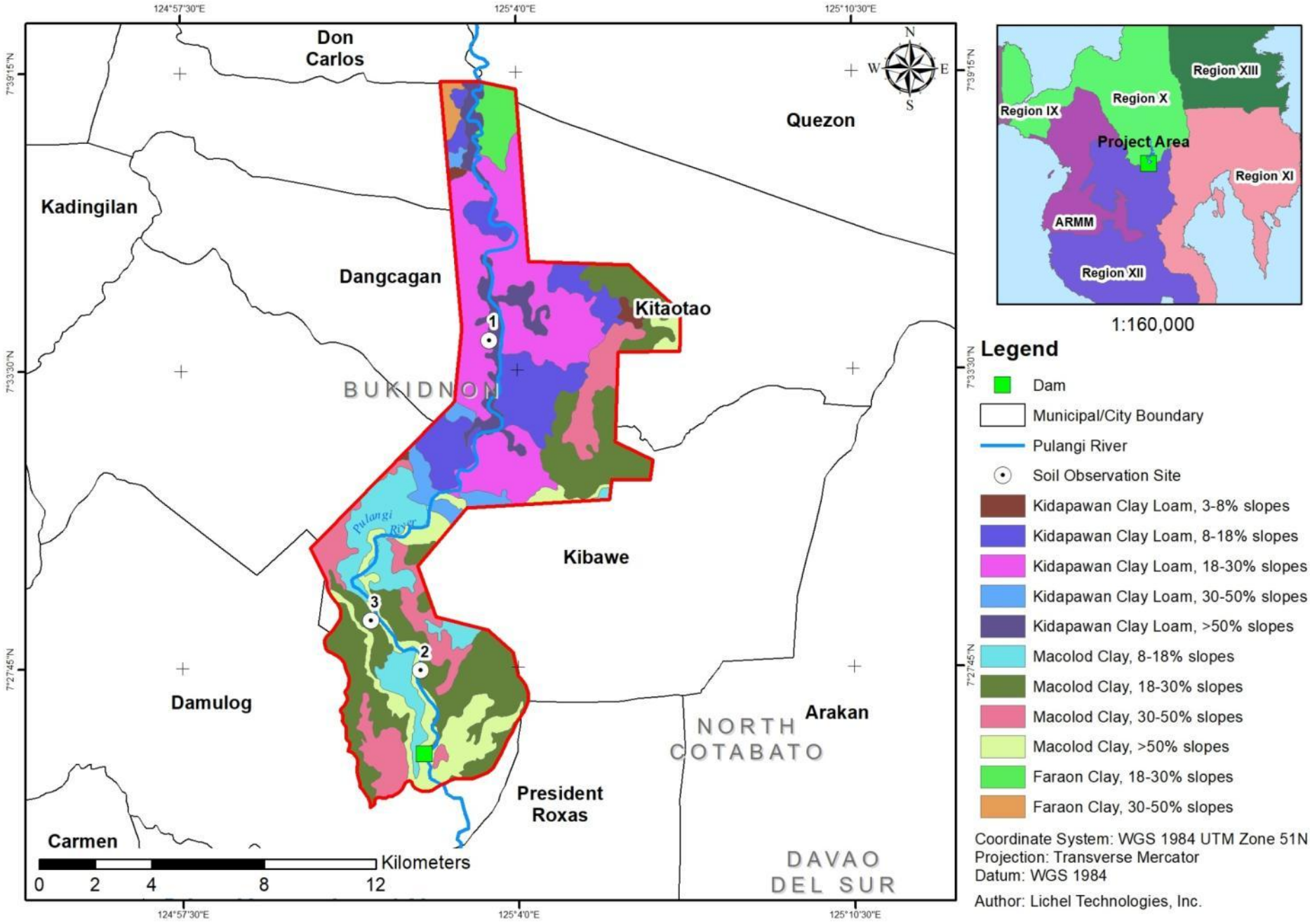

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FIGURE TITLE :

Soils Map

FIGURE NO.:

2-10

Macolod clay, 30-50% slopes occurs in the southern part of the project area both sides of the Pulangi River banks, and at the middle part, eastern side in the Municipality of Kitaotao.

Macolod clay, >50% slopes occurs on the very steep slopes of the Pulangi River banks in the southern part in the Municipalities of Damulog and Kibawe.

Faraon clay, 18-30% slopes occurs at the northern part of the project area, eastern side.

Faraon clay, 30-50% slopes occurs at the northern part of the project area, western side.

Kidapawan clay loam, 18-30% slopes as represented by soil observation no.1 is a well drained, deep clay loam soil (**Table 2-6**). Soil reaction is medium acid (pH 5.6). Total Nitrogen and Organic matter are very low with 0.118% and 2.1%, respectively. Total Phosphorus is 465 mg/kg.Total Potassium is 534 mg/kg. Based on Total Nitrogen and Organic matter, the natural fertility of this soil is low. The heavy metal Arsenic with 2.26 mg/kg, Cadmium with <0.4 mg/kg, Lead with 19.6 mg/kg, Mercury with 0.1000 mg/kg, Copper with 97.4 mg/kg, and Zinc with 125 mg/kg are below the contamination level as prescribed by the Taiwanese standards of 40 mg/kg for Arsenic, 5 mg/kg for Cadmium, and 500 mg/kg for Lead, 2mg/kg for Mercury, 200mg/kg for Copper, and 500 mg/kg for Zinc respectively. Manganese with 1,111 mg/kg is within the range of Manganese in soil of 30-5000 mg/kg. Iron with 0.14 % is below the range of iron in soil of 0.3-10%, Chromium Hexavalent with 11 mg/kg is above the contamination level as prescribed by the U. S. EPA standard of 2mg/kg.

Macolod clay, 18-30% slopes as represented by soil observation 2 and 3 is a well drained deep clay soil. Soil reaction is neutral to strongly alkaline with pH 7.2 to 8.8, respectively. Nitrogen is very low (0.088 and 0.07 %). Organic matter is low to very low with 2.5% to 1.5%, respectively. Total Phosphorus is 4,750 and 1,291 mg/kg for observation 2 and 3, respectively. Total Potassium is 4,573 and 3,630 mg/kg for observation 2 and 3, respectively. Based on Total Nitrogen and Organic matter, the natural fertility of this soil is low. The heavy metal Arsenic with 2.09 and 2.27 mg/kg, Cadmium with <0.4 mg/kg, Lead with 26.5 and 29.7 mg/kg, Mercury with 0.20 and 0.57 mg/kg, Copper with 51.1 and 92.3 mg/kg, and Zinc with 111 and 115 mg/kg are below the contamination level as prescribed by the Taiwanese standards of 40 mg/kg for Arsenic, 5 mg/kg for Cadmium, and 500 mg/kg for Lead, 2mg/kg for Mercury, 200 mg/kg for Copper, and 500mg/kg for Zinc, respectively. Manganese with 499 and 1099 mg/kg are within the range of Manganese in soil of 30-5000 mg/kg. Iron with 0.07 and 0.18 % are below the range of iron in soil of 0.3-10%. Chromium Hexavalent with 5.5 and 4.5 mg/kg are above the contamination level as prescribed by the U. S. EPA standard of 2 mg/kg.

Faraon clay, 18-30 and 30-50% slopes is a moderately well drained to well drained shallow clay soil. Soil reaction is strongly acid with pH 5.5.Total Nitrogen is medium with 0.23%.

Table 2-6: Soil Physical and Chemical Properties

	Kidapawan clay loam, 18-30% slopes (Observation 1)	**Macolod clay , 18-30% slopes (Observation 2)**	**Macolod clay, 18-30% slopes (Observation 3)**	**Faraon clay , 18-30 & 30-50% slopes**
Physical Properties				
Soil Texture	Clay loam	Clay	Clay	Clay
Slope (%)	18-30	18-30	18-30	18-30 & 30-50
Drainage*	Well drained	Well drained	Well drained	Moderately well to well drained
Soil Depth (cm)	>100	>100	>100	30-50
Chemical Properties				
pH	6.9	7.2	8.8	5.5
Nitrogen (%)	0.118	0.088	0.07	0.23
Organic Matter (%)	2.1	2.5	1.5	-
TotalPhosphorus (mg/Kg)****	465	4750	1291	-

TotalPotassium (mg/Kg)****	534	4573	3630	-
Heavy Metals (mg/kg)				
Arsenic	2.26	2.09	2.27	-
Cadmium	<0.4	<0.4	<0.4	-
Lead	19.6	26.5	29.7	-
Mercury	0.10	0.20	0.57	-
Copper	97.4	51.1	92.3	-
Zinc	125	111	115	-
Manganese	1111	499	1099	-
Iron (%)	0.14	0.07	0.18	-
Chromium Hexavalent	11	5.5	4.5	-

*Drainage (FAO):
Well Drained - water is removed from the soil readily but not rapidly. Kidapawan clay loam and Macolod clay are well drained soils that are within the project area.
Moderately Well Drained – water is removed from the soil somewhat slowly, so that the profile is wet for a small but significant part of the time.

** Surface soil (0-20cm depth)
*** Lifted from Soil Survey Report of Bukidnon Province
**** For repeat analysis using other method

Taiwan standards for assessment of soil contaminated with heavy metals (mg/kg):
Arsenic=40; Cadmium= 5; Lead=500; Mercury=2; Copper = 200; Zinc = 500
Range of Manganese and Iron in soil:
Manganese = 30- 5000mg/kg; Iron = 0.3- 10% (Leeper, 1978)
Chromium Hexavalent = 2mg/kg (U.S. EPA, 2010)

2.1.3.2 Change in Soil Quality/ Fertility

2.1.3.2.1 Soil Suitability Classification

A qualitative suitability classification was made by comparing the plants environmental requirements with the physico- chemical properties of the soil mapping units (**Table 2-6** and **Table 2-7**, **Annex 1**: Service Contract from DOE

Annex 2**).**

Results showed that the forest tree species (Narra, Molave, Mahogany, Manguim and Auriculiformis) are suitable on Kidapawan clay loam with 3-8, 8-18, 18-30, 30-50 and .>50% slopes, Macolod clay with 8-18, 18-30, 30-50 and >50% slopes, and Faraon clay, 18-30, 30-50% slopes, but with low soil fertility as the limitation. The fruit bearing trees (Coffee, Breadfruit/Rimas, Coconut and Jackfruit) are suitable on Kidapawan clay loam with 3-8, 8-18, 18-30 % and 30-50% slopes, Macolod clay with 8-18, 18-30, 30-50% slopes and Faraon clay with 18-30, 30-50% slopes, but with low soil fertility as the limitation (**Table 2-7**). Breadfruit, Coconut, Jackfruit and Coffee are not suitable on Kidapawan clay loam and Macolod clay with >50% slopes. Citrus is suitable on Kidapawan clay loam with 3-8, 8-18, 18-30% slopes, Macolod clay with 8-18, 18-30% slopes, and Faraon clay with 18-30% slopes, with low soil fertility as the limitation, but not suitable on Kidapawan clay loam, Macolod clay and Faraon clay with >30% slopes.

Corn and Sugarcane are suitable on Kidapawan clay loam with 3-8% slopes with low soil fertility as the limitation. These crops are not suitable on Kidapawan clay loam, Macolod clay and Faraon clay with > 8% slopes.

Table 2-7: Environmental Requirements of Selected Plants

Plant	Slope (%)	Soil Depth (cm)	Drainage	Soil pH	Soil Texture	Soil Fertility
Narra	0>50	≥45	Moderately well	4.5-7.5	Loamy to structured clay	Low to medium
Molave	0>50	≥45	Moderately well to well drained	4.5-7.5	Loamy to clay	Low to medium
Mahogany	0>50	≥45	Moderately well to well drained	5.0-7.5	Loamy to clayey	Low to medium
A.Manguim	0>50	≥45	Moderately well to well drained	4.0-7.5	Sandy loam to clay loam	Low to medium
A.Auriculiformis	0>50	≥45	Moderately well to well drained	4.0-7.5	Sandy loam to clay loam	Low to medium
Coconut	0-50	≥70	Moderately well drained	5.5-7.5	Sandy loam to clay loam	Medium
Breadfruit“Rimas”	0-50	≥45	Moderately well to well drained	4.5-7.5	Loamy to clayey	Low to medium
Jackfruit	0-50	≥45	Moderately well to well drained	4.5-7.5	Loamy to clayey	Low to medium
Citrus(Mandarin/Calamansi)	0-30	≥70	Moderately well to well drained	4.5-6.5	Sandy loam to clayey	Medium
Coffee	0-50	≥45	Moderately well to well drained	4.5-7.0	Sandy loam to clay	Low to Medium
Corn	0-8	>100	Moderately well to well drained	4.5-8.5	Sandy loam to clay	Medium
Sugarcane	0-8	>100	Moderately well to poorly drained	4.5-8.5	Sandy loamy to clayey	Medium

Table 2-8: Qualitative Suitability Classification

	Soil type/ Soil Mapping Unit**										
	KdclB	KdclC	KdclD	KdclE	KdclF	MacC	MacD	MacE	MacF	FacD	FacE
Narra	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*
Molave	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*
Mahogany	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*
Manguim	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*
Auriculiformis	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*	S*
Coconut	S*	S*	S*	S*	NS	S*	S*	S*	NS	S*	S*
Breadfruit/Rimas	S*	S*	S*	S*	NS	S*	S*	S*	NS	S*	S*
Jackfruit	S*	S*	S*	S*	NS	S*	S*	S*	NS	S*	S*
Citrus (Mandarin/Calamansi)	S*	S*	S*	NS	NS	S*	S*	NS	NS	S*	NS
Coffee	S*	S*	S*	S*	NS	S*	S*	S*	NS	S*	S*
Corn	S*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sugarcane	S*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

S=Suitable
NS=Not suitable
*Suitable but with low soil fertility as limitation
**KdclB = Kidapawan clay loam, 3-8% slopes
KdclC= Kidapawan clay loam, 8-18% slopes
KdclD= Kidapawan clay loam, 18-30% slopes
KdclE= Kidapawan clay loam, 30-50% slopes
KdclF= Kidapawan clay loam, >50% slopes
MacC= Macolod clay, 8-18% slopes
MacD= Macolod clay, 18-30% slopes
MacE= Macolod clay, 30-50% slopes
MacF= Macolod clay, >50% slopes
FacD= Faraon clay, 18-30% slopes
FacE= Faraon clay, 30-50% slopes

2.1.3.2.2 Soil Erosion Susceptibility of the Project Area

The four contributing factors to erosion include rainfall, soil erodibility, vegetation/ landuse and slope. To determine the extent of erosion susceptibility within the project area, three (3) degrees of susceptibility are defined for each of the four contributing factors. These are “slightly susceptible” “moderately susceptible” and “highly susceptible”.

Rainfall

For rainfall, the degree rating is shown in **Table 2-9.** Appendix Table 1 shows the rainfall data of Malaybalay, Bukidnon. Data shows that there are six (6) wet months (with more than 200 mm. /mo.) with July as the wettest month having 329.4 mm of rainfall. The remaining six (6) months are with low rainfall with January having the least rainfall of 181.3 mm. Based on these rainfall data, the erosion susceptibility rating for the whole project area is “moderate”.

Table 2-9: Erosion Susceptibility based on Rainfall

Degree of Susceptibility	Rainfall Type
Slightly	Areas with 5 to 6 dry months and 3 to 4 wet months
Moderately	Areas with 5 to 6 dry months and 5 to 6 wet months
	Areas with 2 to 4 dry months and 5 to 6 wet months

Degree of Susceptibility	Rainfall Type
Highly	Areas with 5 to 6 dry months and 3 to 4 wet months with one or more months of 500mm or more rainfall per month
	Areas with 5 to 6 dry months and 5 to 6 wet months with one or more months of 500mm or more rainfall per month

Source: Bruce

Soil Properties

For soil type, the susceptibility score is shown in **Table 2-10.** The criteria that were used are the soil depth and clay-silt fraction. Kidapawan clay loam and Macolod clay is with deep soils (>100cm soil depth) and 0- 60% clay-silt fraction. Kidapawan clay loam and Macolod clay are with “moderate susceptibility to erosion”. Faraon clay with shallow soil and > 60% clay-silt fraction is with “high susceptibility to erosion”.

Table 2-10: Erosion Susceptibility based on Soil Properties

Degree of Susceptibility	Soil Depth and Texture
Slightly	Areas with 50 to 100cm solum and 60 to 100% clay-silt fraction
	Areas with greater than 100cm solum and 0 to 60 percent clay-silt fraction
	Unclassified soils of the mountain
Moderately	Areas with 50 to 100cm solum and 0 to 60% clay-silt fraction
	Areas with greater than 100cm solum and 60 to 100% clay-silt fraction
Highly	Areas with less than 50cm solum and 0 to 100% clay-silt fraction

Notes: Solum is made up of surface soil and subsoil. Clay-silt fraction is percent total of clay and silt particles determined through mechanical analysis of topsoil.
Source: Bruce

Land Use/Vegetation

For landuse/vegetation, the degree rating is shown in **Table 2-11,** as shown by landuse/vegetation map of the project area (**Figure 2-1**), there are seven (7) landuse/vegetation types identified in the project area. Based on Table 5.3, the areas with Tree Plantation; forest; shrubland; and the Built-up areas are with “slight susceptibility to erosion”. The grassland is with “moderate susceptibility to erosion”. The Annual crops and Coconut with annual crops are with “high susceptibility to erosion”.

Table 2-11: Erosion Susceptibility based on Vegetation and Crops Grown

Degree of Susceptibility	Type of Crops/Ground Cover
Slightly	Areas grown to paddy rice
	Areas permanently planted to coconut, mixed orchard, fruit trees, etc.
	Areas covered with dense forest/shrubs, tall grasses and pine trees
Moderately	Areas grown to sugar cane
	Open grassland
	Areas with thin growth of deciduous forest with scattered kaingin clearings Areas, sloping planted to coconut or fruit trees intercropped with upland row crops (corn, cassava, sweet potato, etc.)
Highly	Areas of diversified upland row crops – corn, cassava, upland rice, mungbean, pineapple, etc.
	Areas planted to tobacco

Degree of Susceptibility	Type of Crops/Ground Cover
	Areas with thin growth of short grasses with patches of kaingin clearings; Sparsely vegetated land; Bare area

Source: Bruce

Slope

As shown by the slope ranges in the soil map (**Figure 2-10**), and based on Table 2-12, Kidapawan clay loam with 3-8% slopes is with "slight susceptibility to erosion". Kidapawan clay loam and Macolod clay with 8-18% slopes are with "moderate susceptibility to erosion". Kidapawan clay loam, Macolod clay and Faraon clay with 18-30, 30-50 and >50% slopes are with "high susceptibility to erosion".

Table 2-12: Erosion Susceptibility based on Slope

Degree of Susceptibility	Slope Range
Slightly	Areas with slope between 0 and 8%
Moderately	Areas with slope between 8 and 18%
Highly	Areas with slope greater than 18%

Source: Bruce

Final Erosion Suseptibility Rating

The four (4) erosion susceptibility ratings of each soil unit are aggregated to form the final rating consistent with **Table 2-13**, which shows the decision rule on the composite or final erosion susceptibility index. The Soil Erosion Susceptibility Map (**Figure 2-11**) displays the result of erosion susceptibility ratings.

The Coconut with Corn and Sugarcane, and Built-up area on Kidapawan clay loam with 3-8% slopes are with "slight susceptibility to erosion"

The Coconut with Corn/Sugarcane, Annual crops, Tree Plantation, and Built-up areas on Kidapawan clay loam with 8-18% slopes; Tree Plantation and Built-up areas on Kidapawan clay loam with 18-30% slopes; Tree Plantation on Kidapawan clay loam with 30-50% slopes; The Forest, Shrubland, and Tree Plantation on Kidapawan clay loam with >50% slopes; Tree Plantation , Annual crops and Built-up areas on Macolod clay with 8-18% slopes; Tree Plantation and Shrubland on Macolod clay with 18-30% slopes; The Shrubland on Macolod clay with 30-50% slopes; and the Forest and Tree Plantation on Macolod clay with >50% slopes are with "moderate susceptibility to erosion". The annual crops on Kidapawan clay loam and Macolod clay with 18-30, 30-50, >50% slopes, and Faraon clay with 18-30% slopes; Coconut with Corn and Sugarcane on Kidapawan clay loam with 18-30% slopes and Macolod clay with 30-50% slopes; The grassland on Kidapawan clay loam with 30-50,>50% slopes; Macolod clay with 18-30, 30-50% slopes; and Faraon clay with 18-30 and 30-50% slopes are with "high susceptibility to erosion".

Table 2-13: Composite Erosion Susceptibility Decision Rule

Individual Susceptibilities (Rainfall – landuse – slope – soil)	Final Degree of Erosion Susceptibility
S – S – S – S	Slightly
M – M – M – M	Moderately
H – H – H – H	Highly
H – M – H – H	Highly
H – S – M – M	Moderately
H – M – M – H	Moderately

Note: S is slightly susceptible, M- moderately susceptible, and H- highly susceptible.

Source: Bruce

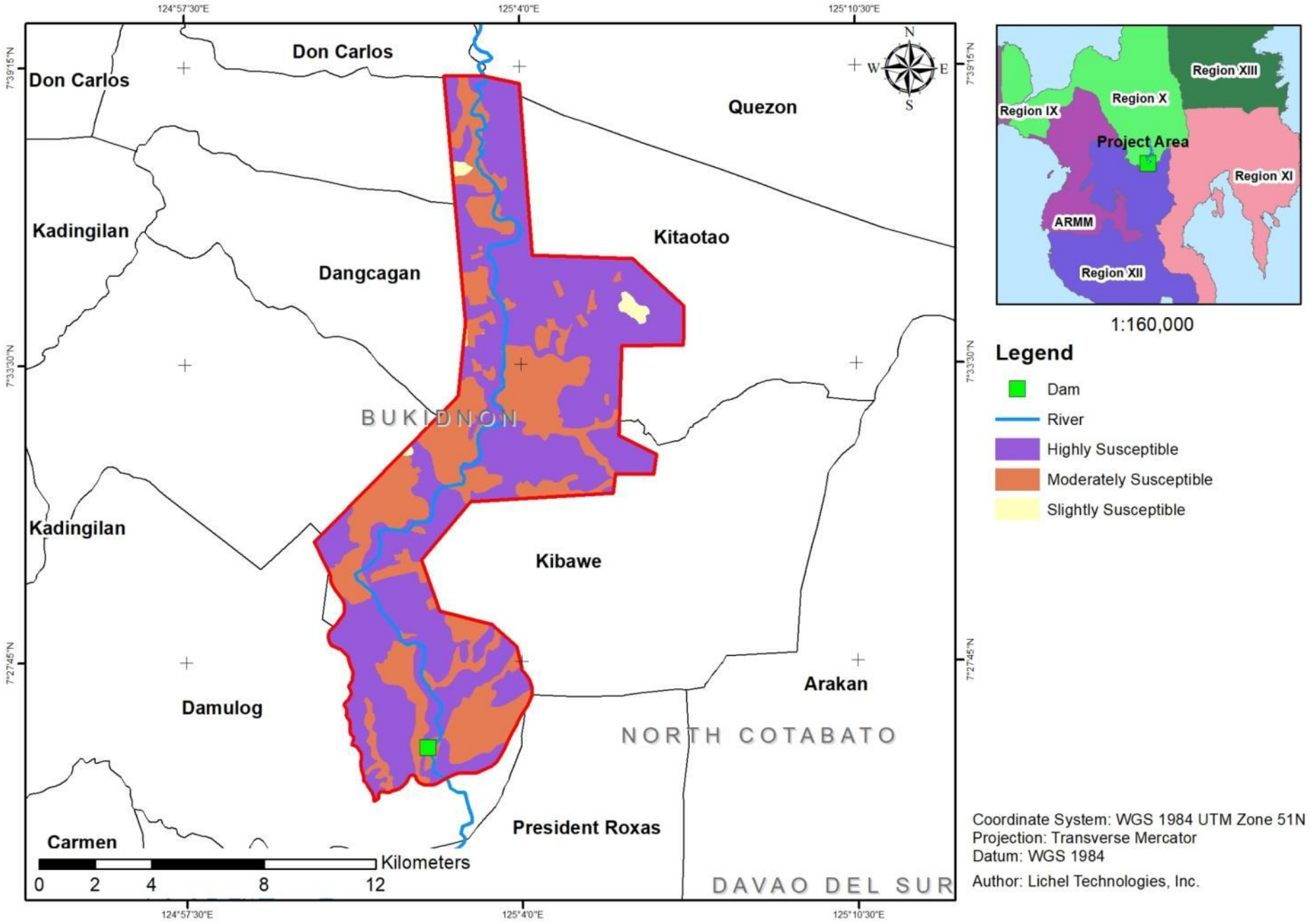

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FIGURE TITLE :

Soil Erosion Susceptibiltiy

FIGURE NO.:

2-11

Summary of Impact Assessment and Mitigation for Soils

The summary of impacts and corresponding mitigation measures for pedology aspect of the environment is shown in **Table 2-14** below.

The clearing of vegetation and excavation works for the construction of the dam and powerhouse will cause soil erosion and sedimentation of the rivers. However this is small in magnitude inasmuch as it is only concentrated on the dam and powerhouse sites and short term. This can be mitigated by keeping the vegetation clearing and excavation to a minimum and what is essential. Further this can be mitigated by scheduling the clearing of vegetation and excavation during the drier months (November to April of the following year)

The soil erosion in the project area and sedimentation of the river and reservoir in the long term is due to the landuse management of annual crops cultivation (Corn and/or Sugarcane) in the project area/watershed. This can be mitigated by proper farm management with proper soil conservation measures that will be instituted in the farms like agroforestry with the use of hedgerows with shrubs/trees.

To ensure the stability of the slopes of the Pulangi River banks, reforestation should be instituted with the use of indigenous species or Balete (*Ficus benjamina*), a versatile tree species that is highly suitable for reforestation of river banks. For river bank with existing trees, coffee can be use as understory trees to enhance the soil surface cover.

Table 2-14: Summary of the Significant Impacts and Mitigation Measures for for Pedology

Potential Impact	P	C	O	A	Options for Prevention, Mitigation, Enhancement
Soil Erosion/Loss of Topsoil/Overburden	√	√	√	√	Soil erosion due to clearing of vegetation and excavation due to Dam and Powerhouse construction can be mitigated by means of keeping the vegetation clearing to a minimum and what is essential, and scheduling of clearing and excavation works during the drier months (November to April of the following year). For erosion in the Project area due to landuse management (Annual crops with Corn and/or Sugarcane), can be mitigated by proper farm manangement with soil conservation measures like Agroforestry with the use of hedgerows that will be instituted in the farms.
Soil Contamination	√	√			Soil contamination due to fuel and oil spillage during the dam/powerhouse construction can be mitigating with proper handling of the materials and proper maintenance of the equipment.
Change in Soil Quality and Fertility	√	√	√	√	The change in soil quality and fertility is associated with the erosion in the project area due to landuse management (annual crop cultivation with Corn/Sugarcane). This can be mitigated by proper farm manangement with soil conservation measures that will be instituted in the farms.

2.1.4 Terrestrial Ecology

2.1.4.1 Vegetation Removal and Loss of Habitat

2.1.4.1.1 Limitations of the Study

To prevent misunderstanding with the IP communities in the proposed project site and due to maintain safety and security for the flora and fauna team, the sampling activities mainly focused on identification through visual encounters, abundance counts and transect walk. As per verbal advice of the Manobo Tribe Leader Datu Bobby sampling for terrestrial ecology was only limited from 8:00 AM until 4:00 PM, while night sampling for herps were strictly prohibited. In addition, any form of traps was also not allowed during the sampling activity.

2.1.4.1.2 Location of Sampling Sites and Land Cover

Various maps were used in the determination of the sampling stations and transect lines for terrestrial flora and fauna. The study area includes those areas affected by the inundation that will be brought about by the proposed dam, and the upper elevation areas where farm lands are dominant. **Table 2-15** show the stations established on the study site, including land cover. **Figure 2-12** to **Figure 2-15** show some of the vegetation found in the sampling stations while **Figure 2-16** shows the locations of the stations and transect lines superimposed on the land cover map. **Figure 2-17** shows the location of the sampling stations on a satellite map, and **Figure 2-18** shows the locations of the sampling stations and transect lines relative to the locations of the proposed dam and inundated lands.

Table 2-15: Established Sampling Points on Representative Land Covers on the Affected Sites of Pulangi Project

Transect Line	Sampling Stations	Coordinates		Location	Land Cover
		Northing	Easting		
Transect 1	T1P1	7°27'30.40"	125°02'01.32"	Kibawe	Arable land, crops mainly cereals and sugar
	T1P2	7°27'00.68"	125°02'04.88"	Kibawe	Cultivated Area mixed with brushland/grassland
	T1P3	7°27'55.04"	125°01'46.88"	Kibawe	Arable land, crops mainly cereals and sugar
Transect 2	T2P1	7°36'0.399"	125°1'13.956"	Dancagan	Crop land mixed with other plantation
	T2P2	7°35'59.871"	125°1'19.935"	Dancagan	Crop land mixed with other plantation
	T2P3	7°35'58.804"	125°1'27.179"	Dancagan	Crop land mixed with other plantation
Transect 3	T3P1	7°36'51.01"	125°3'37.059"	Kitaotao	Arable land, crops mainly cereals and sugar
	T3P2	7°36'47.172"	125°3'38.765"	Kitaotao	Arable land, crops mainly cereals and sugar
	T3P3	125°3'39.435"	7°36'42.301"N	Kitaotao	Other plantations
Transect 4	T4P1	7º25' 22.4"	125º22.34.8"	Damulog	Cultivated Area mixed with brushland/grassland
	T4P2	7º25' 13.7"	125º22' 37.4"	Damulog	Cultivated Area mixed with brushland/grassland
	T4P3	7°27'30.40"	125°02'01.32"	Damulog	Cultivated Area mixed with brushland/grassland

1. *Kleinhovia hospita* 2. *Paraserianthes falcataria* 3. *Macaranga tanarius* 4. *Acalypha amantacea*

Figure 2-12: Vegetation in Stations and Transect of T1P1 - T1P3

1. *Cratoxyllum celebicum* 2. Buchanania heterophylla 3. Artocarpus oedoratissimus 4. Melanolepis

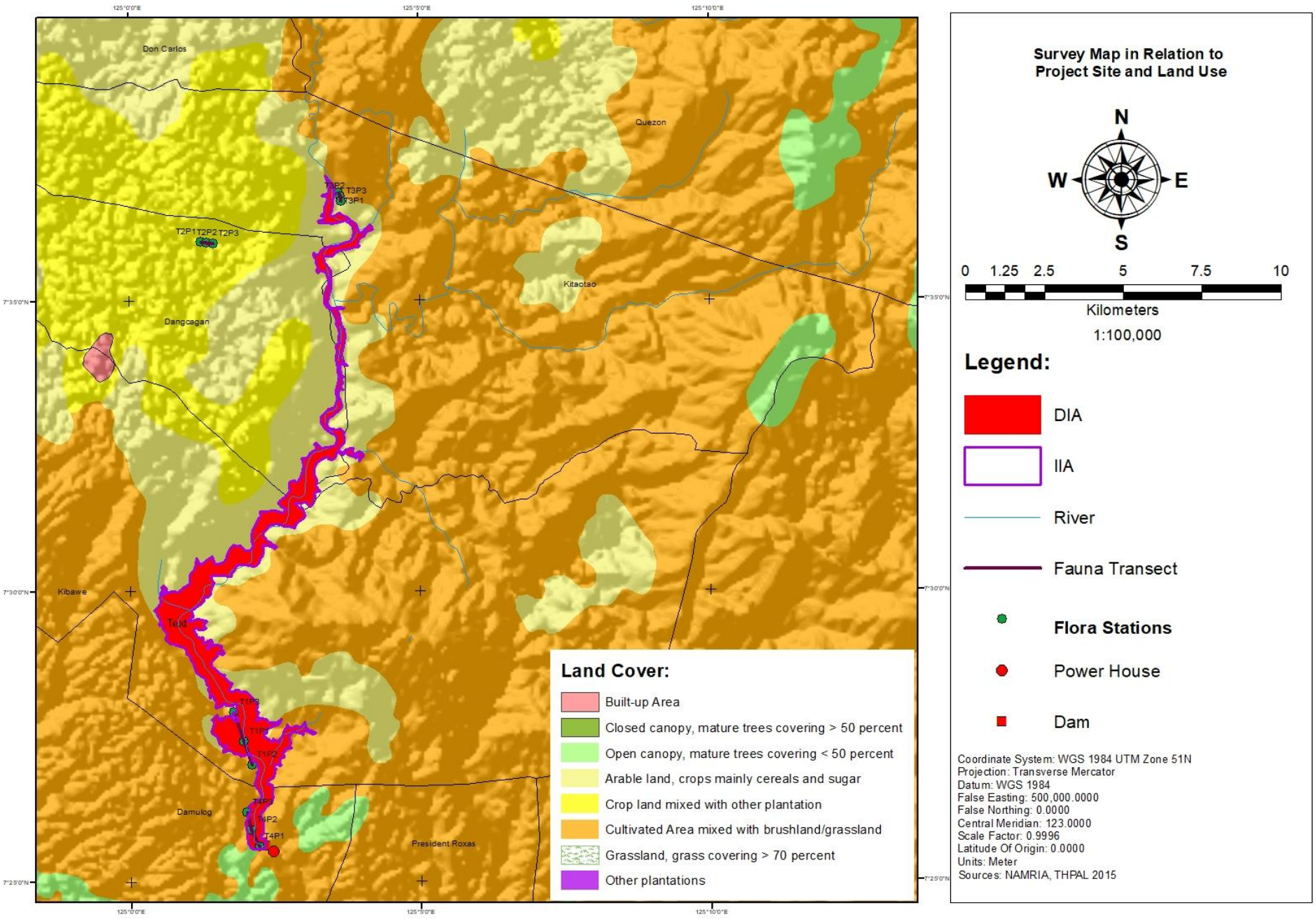
Figure 2-13: Vegetation in Stations and Transects of T2P1 – T2P3

1. *Artocarpus camansi* 2. *Polyscias nodosa* 3. *Mallotus* sp. 4. *Poikilospermum* sp. 5. *Zea mays* 6. *Cananga odorata* 7. *Artocarpus* sp. 8. *Ficus congesta* 9. *Embelia* sp.

Figure 2-14: Vegetation in Stations and Transects of T3P1 – T3P3

1. *Rollinia deliciosa* 2. *Euphorbia hirta* 3. *Senna spectabilis* 4. *Musa* sp. (Abaca) 5. *Vitex pinnata* 6. *Terminalia* sp. 7. *Musa* sp. (Hybrid banana) 8. *Ficus* sp.

Figure 2-15: Vegetation in Stations and Transects of T4P1 – T4P3



Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

Terrestrial Flora Sampling Stations on Land Cover Map

FIGURE NO.:

2-16

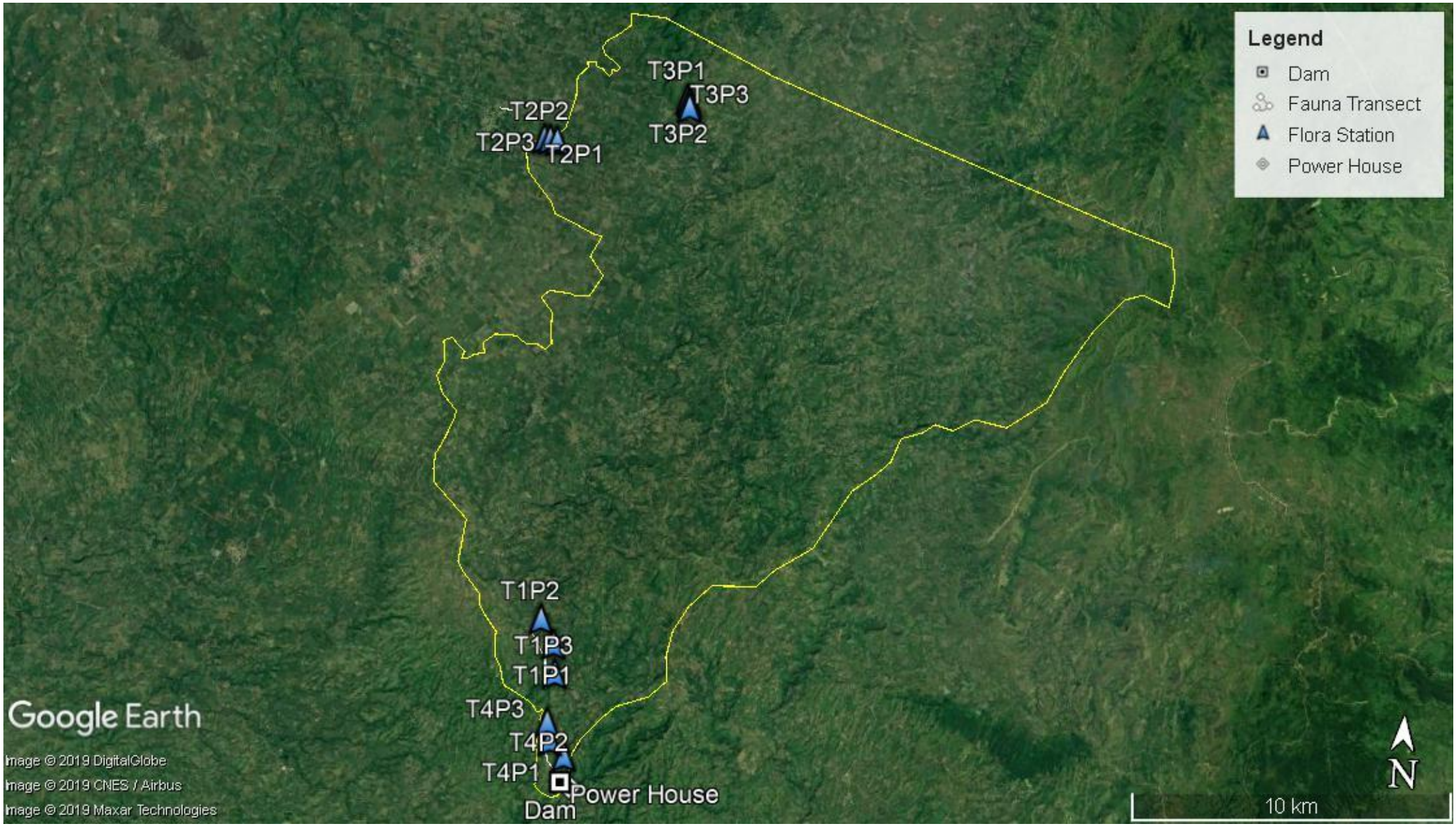


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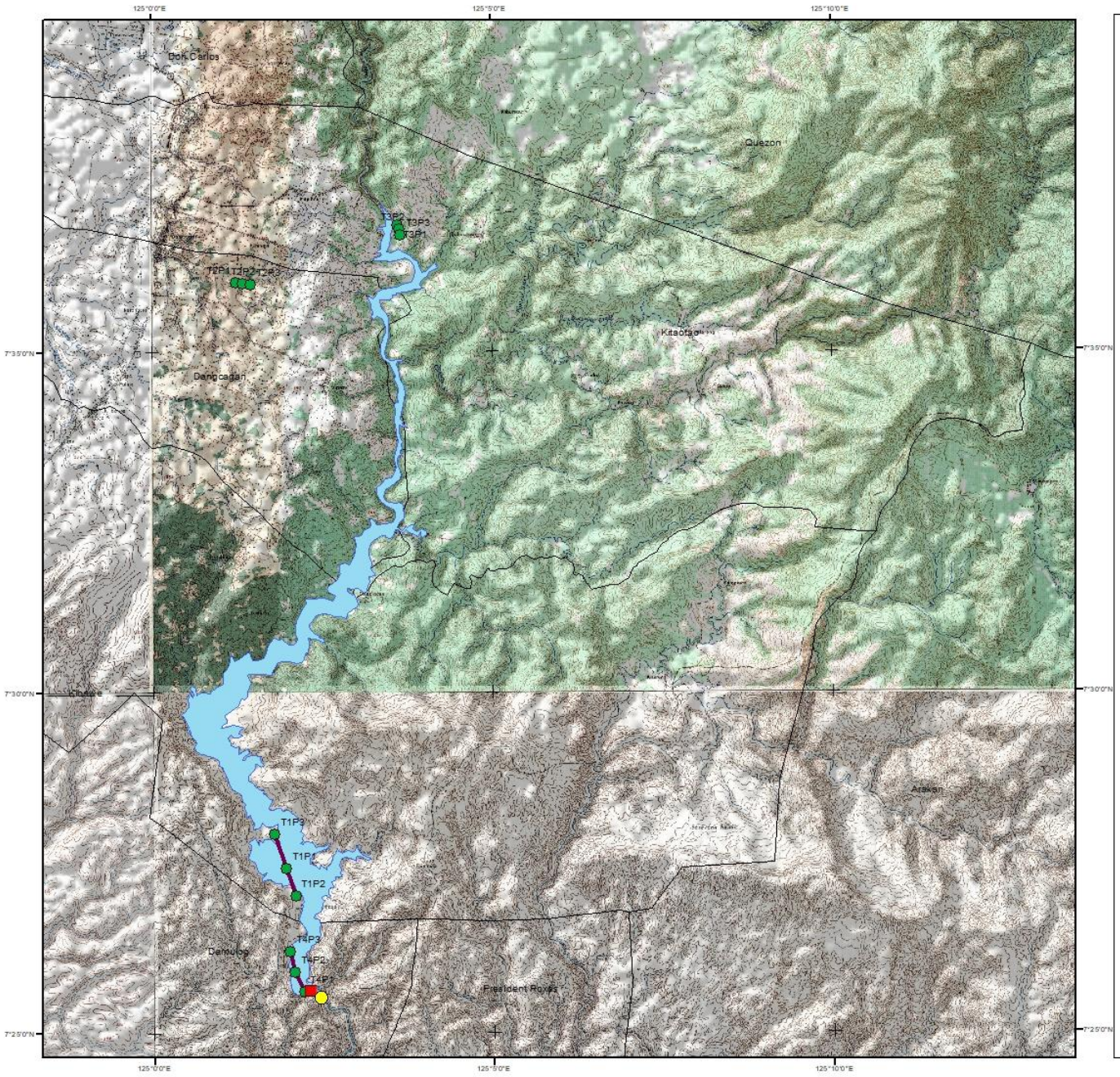
FIGURE TITLE :

Terrestrial Flora and Fauna Sampling Stations on Google Map

FIGURE NO.:

2-17



Survey Map in Relation to Project Site and Land Use

N
W E
S

0 1.25 2.5 5 7.5 10

Kilometers

1:100,000

Legend:

- Power House
- Dam
- **Flora Stations**
- Fauna Transect
- Reservoir

Coordinate System: WGS 1984 UTM Zone 51N
Projection: Transverse Mercator
Datum: WGS 1984
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: 123.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter
Sources: NAMRIA, THPAL 2015

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FIGURE TITLE :

Terrestrial Flora and Fauna Sampling Stations in Relation to Project Development

FIGURE NO.:

2-18

2.1.4.1.3 Methodologies

Due to restrictions by the IP communities in the terrestrial flora survey, A modified Transect Walk with Plot-less Sampling Method (Knapp, 1984) was used in the assessment. According to Barbour et al. (1987), Plot-less sampling methods could be thought of as quadrats shrunk to a line or a point of no dimension. The method involves establishing a transect line approximately 2 km in length and establishing three stations within the transect line with 1-km intervals. On the stations, all visible and identifiable flora species were listed with abundance counts. This maximizes the number of flora species encountered during the survey, providing the composition of the vegetation in the proximity of the station. Within the 2-km transect line, transect walk method was also conducted, listing species not included within the established stations.

Opportunistic Sampling Method, on the other hand, was used in the survey of terrestrial fauna for all faunal assemblages (Birds, Mammals and Herps). This involves the establishment of a 2-km transect line, and listing all species encountered during the transect walk. Direct methods of identification using catch and release were not utilized in the assessment due to the restrictions imposed by the indigenous people's communities, prohibiting the use of any form of traps for the survey. Indirect methods of identification through bird calls, sounds, tracks, droppings and feces were also used in the assessment. Interviews with local guides were also conducted. All fauna species encountered were identified, listed and counted.

Parameters used in the assessment of terrestrial flora and fauna include the following:

$$Abundance\ (Abund) = Number\ of\ individuals\ in\ a\ species$$

$$Frequency\ (Freq) = \frac{Number\ of\ times\ a\ species\ occurred\ in\ all\ points}{Total\ number\ of\ points} \times 100$$

$$Relative\ Abundance\ (RAbund) = \frac{Abund}{Total\ Abundance} \times 100$$

$$Relative\ Frequency\ (RFreq) = \frac{Freq}{Total\ Frequency} \times 100$$

$$Importance\ Value\ (IV) = \frac{RAbund + RFreq}{2}$$

Importance values would determine the ranks of the species within the sampled ecosystem and would identify which of them would be exerting the most influence on the ecosystem in terms of nutrient cycling, energy transfer, and micro-climatic effects.

Biodiversity Indices were used to determine the dominance and distribution of species found in the area. The indices used are as follows:

Dominance (D) is a measure ranging from 0 to 1, the former indicating if all taxa are equally present, or the latter, if one taxon completely dominates the community.

$$D = \sum_{i=1}^{S} \left[\left(\frac{n_i}{N} \right)^2 \right]$$

Shannon-Weiner Index (H') is a measure of the average degree of "uncertainty" in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong (Magurran 1988).

$$H' = \sum_{i=1}^{S} \left[\left(\frac{n_i}{N} \right) \ln \left(\frac{n_i}{N} \right) \right]$$

Pielou's Evenness Index (J') expresses H' relative to the maximum value that H' can obtain when all of the species in the sample are perfectly even with one individual per species (Magurran 1988).

$$J' = \frac{H'}{\ln(S)}$$

Paleontological Statistics (PaST) V.10 software was used in the computations of the diversity parameters and indices.

The computed values were then related to the Fernando Biodiversity Scale (1998) shown in **Table 2-16**.

Table 2-16: The Fernando Biodiversity Scale

Relative Values	Shannon (H') Index	Pielou (J') Evenness Index
Very High	3.5 and above	0.75-1.00
High	3.0-3.49	0.50-0.74
Moderate	2.5-2.99	0.25-0.49
Low	2.0-2.49	0.15-0.24
Very Low	1.9 & below	0.05-0.14

2.1.4.1.4 Terrestrial Flora Biodiversity

Overall, a total of 1,413 individuals with 72 species and 42 families were observed in the stations of the municipalities assessed for the Project. Overall dominance is at D = 0.09 which indicated that species were evenly distributed throughout the areas assessed. Diversity and evenness are both High at H' = 3.14 and J' = 0.73. Table 2-17 shows the summary of results for Terrestrial Flora Survey.

Table 2-17: Summary of Results for Terrestrial Flora Diversity

Parameters	Kibawe	Dancagan	Kitaotao	Damulog	Overall
No. of Individuals	570	363	174	306	1413
Species Richness	30	26	29	33	72
No. of Families	23	19	20	24	47
Dominance	0.10	0.14	0.34	0.10	0.09
Diversity Index (H')	2.70	2.47	2.04	2.77	3.14
Evenness Index (J')	0.79	0.76	0.60	0.79	0.73

2.1.4.1.4.1 Species Abundance

A total of 1413 individuals were listed in the assessment with the highest number of individuals found in Kibawe Municipality. As the area was dominated by cultivated lands, corn obtained the highest number of individuals for the whole survey with 300 individuals in the Municipalities of Kibawe, Kitaotao and Dancagan. Saging saba, on the other hand, was ranked second and were present in all 4 transects. Niog was ranked third in abundance and then followed by Saging. The checklist for terrestrial flora species is found **Annex 5.**

Table 2-18: Abundance of Flora Species Found on the Assessed Municipalities

Scientific Name	Common Name	Kibawe	Dancagan	Kitaotao	Damulog	Abundance
Zea mays	Corn/mais	100	100	100		300
Musa paradisiaca	Saging saba	115	81	3	49	248
Cocos nucifera L.	Niog	38	21	6	31	96
Musa sp.	Saging				52	52
Kleinhovia hospita L.	Tan-ag	19	19		13	51
Chromolaena odorata (L.) R.M.King & M. Robinson	Gonoy	51				51
Musa sp.	Cavendish	51				51
Piper aduncum	Buyo-buyo	11	14		18	43
Manihot esculenta	Cassava				42	42
Cordyline terminalis (L.) Kunth.	Baston de San Jose	15			15	30
Gmelina arborea Roxb.	Yemane	19	3	6		28
Mimosa pudica L.	Makahiya	21	6			27
Paraserianthes falcataria (L.) Nielsen	Moluccan sau		24			24
Castilla elastica Cerv.	Panama rubber	21				21
Mimosa invisa Mart.	Makahiya-lalaki	21				21
Gliricida sepium (Jacq.) HBK.	Madre-cacao	5	5	6	4	20
Artocarpus heterophyllus Lamk.	Nangka	8		3	6	17
Selaginella sp.	-		17			17
Carica papaya L.	Papaya	7		4	5	16
Melicope latifolia	-		16			16
Mikania cordata (Burm.f.) B.L.Rob.	Uoko	16				16
Psidium guajava L.	Bayabas		4	3	6	13
Centrosema pubescens Benth.	-	13				13
Macaranga tanarius (L.) Muell.-Arg.	Binunga	4	4	2	2	12
Sandoricum koetjape (Burm. F.) Merr.	Santol			2	8	10
Artocarpus odoratissimus Blanco	Marang-banguhan		3	4	2	9
Ficus ulmifolia L.	is-sis		6	3		9
Leucaena leucocephala (Lam.) de Wit	Ipil-ipil	3		3	3	9
Annona muricata L.	Guyabano	5			4	9
Ficus sp.	-		4	1	3	8
Ficus septica Burm.f	hauili		4	4		8
Muntingia calabura L.	Datilies	6		2		8
Trema orientalis (L.) Blume	Anabiong				8	8
Alocasia macrorrhizos (L.) G.Don	Biga		4	1	1	6
Melanolepis multigladulosa (Reinw. Ex Blume) Reichb. & Zoll.	Alim	1	5			6
Polyscias nodosa (Blume) Seem	Malapapaya		3	3		6
Vitex pinnata	Tugas				5	5
Terminalia catappa L.	Talisai	5				5
Theobroma cacao L.	Cacao				5	5
Artocarpus camansi	Kamansi			2	2	4

Scientific Name	Common Name	Kibawe	Dancagan	Kitaotao	Damulog	Abundance
Chrysophyllum cainito L.	Star apple			2	2	4
Artocarpus blancoi (Elmer) Merr.	Antipolo	4				4
Leea sp.	-		4			4
Lygodium circinnatum (Burm. f.) Sw.	Nitong puti		4			4
Mallotus mollissimus (Geisl.) Airy Shaw	Hinlaumo		4			4
Terminalia sp.	Talisai				4	4
Alocasia sp.	-		3			3
Capsicum sp.	Sili		3			3
Ficus nota (Blco.) Merr.	Tibig			3		3
Senna spectabilis	Caballero				3	3
Durio zibethinus Murray	Durian			1	1	2
Bambusa blumeana Schult.f.	Kauyan-tinik				2	2
Bixa orellana L.	Achuete	2				2
Citrus grandis (L.) Osb.	Lukban	2				2
Citrus nobilis Lour.	Naranjita			2		2
Coffea arabica L.	Kape				2	2
Dendrocalamus giganteus wallich ex Munro	Giant bamboo				2	2
Morinda citrifolia L.	Bangkoro			2		2
Moringa oleifera Lam.	Malunggai	2				2
Pittosporum sp.	-		2			2
Rollinia deliciiosa Saff.	Biriba				2	2
Saribas rotundifolia	Anahau				2	2
Solanum torvum	-			2		2
Swietenia mahagoni (L.) Jacq.	mahogany	2				2
Tamarindus indica L.	Sampalok	2				2
Artocarpus sp.	Wild marang			1		1
Caryota sp.	Fish tail			1		1
Dracontomelon dao (Blco.) Merr. & Rolfe	Dao				1	1
Mangifera indica L.	Mangga			1		1
Pterocarpus indicus L.	Narra			1		1
Vitex negundo	Lagundi				1	1
Vitex parviflora Juss.	Molave	1				1
Total		**570**	**363**	**174**	**306**	**1413**

2.1.4.1.4.2 Species Richness

In total, 133 flora species were identified and listed on the assessed municipalities. Damulog obtained the highest number of species at 33 species then followed by Kibawe municipality with 30 species. Kitaotao Municipality was ranked third with 29 species and the least number of species was found in Dancagan Municipality with 26 species. **Figure 2-19** shows the comparison of species richness per municipality.

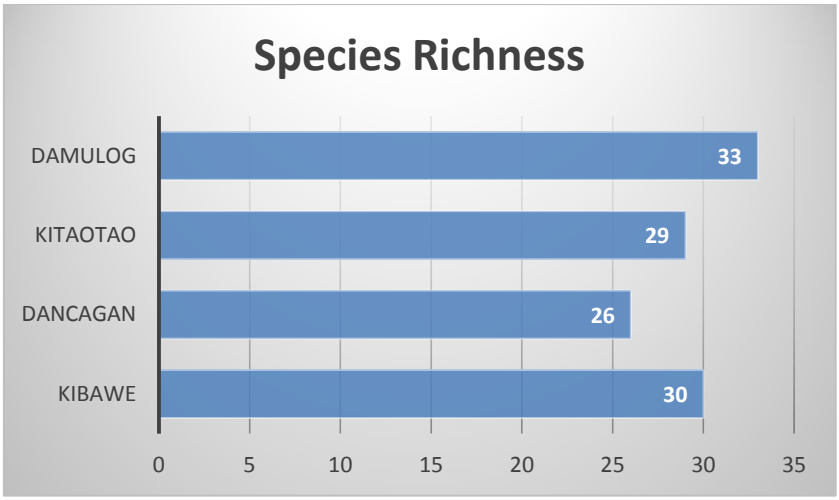


Figure 2-19: Species Richness of Terrestrial Flora in the Assessed Municipalities

2.1.4.1.4.3 Dominance

Dominance (D) determines if all taxa are well represented (D=0) or if one taxon dominates the community (D = 1). As seen in **Figure 2-20**, Dominance is highest in Kitaotao Municipality where D = 0.34. This indicates that in all municipalities assed, Kitaotao exhibited a taxon which dominates the community compared to other species in Kitaotao Municipality. Other municipalities exhibited less values of D with Damulog, Dancagan, and Kibawe Municipalities having values of D = 0.14, D = 0.10 and D=0.10, respectively. This indicated that these municipalities have well represented number of species compared to Kitaotao Municipality.

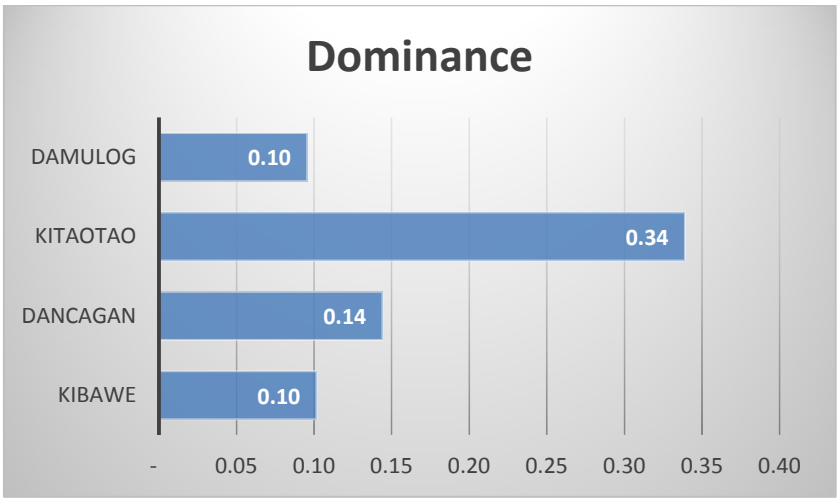


Figure 2-20: Dominance of Species found in the Assessed Municipalities

2.1.4.1.4.4 Diversity Index

Overall diversity of the plant species in the project area is High at H' = 3.14. In terms of diversity per municipality, Damulog obtained the highest diversity value at H' = 2.77 which is considered to be Moderate in the Fernando Biodiversity Scale. Kibawe Municipality closely follows with High diversity at H' = 2.70 and then by Dancagan Municipality with Moderate diversity at H' = 2.47. The Municipality

with the least diversity value is found in Kitaotao with Low diversity at H' = 2.04. **Figure 2-21** shows the comparison of diversity indices of plant communities in the assessed municipalities.

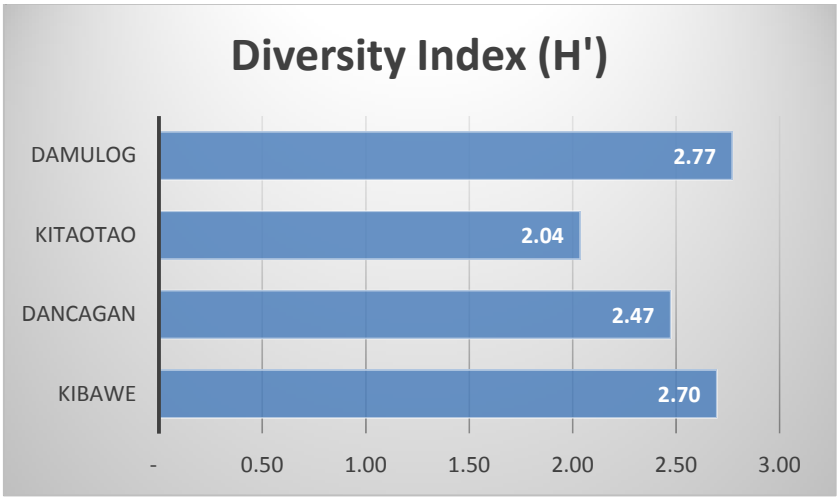


Figure 2-21: Diversity Indices of Plant Communities in the Assessed Municipalities of the Project

2.1.4.1.4.5 Evenness Index

Overall evenness is High at J' = 0.73 in the assessed Municipalities. This indicates that it is Highly likely that all species have equal numbers in the assessed areas. As seen in **Figure 2-22**, evenness indices are Very High for Damulog, Kibawe and Dancagan Municipalities at J' = 0.79, J' = 0.79 and J' = 0.76, respectively, while Kitaotao Municipality exhibited High evenness at J' = 0.60. This indicates that Plant communities in Kitaotao municipality are more clustered compared to plant communities in other assessed municipalities.

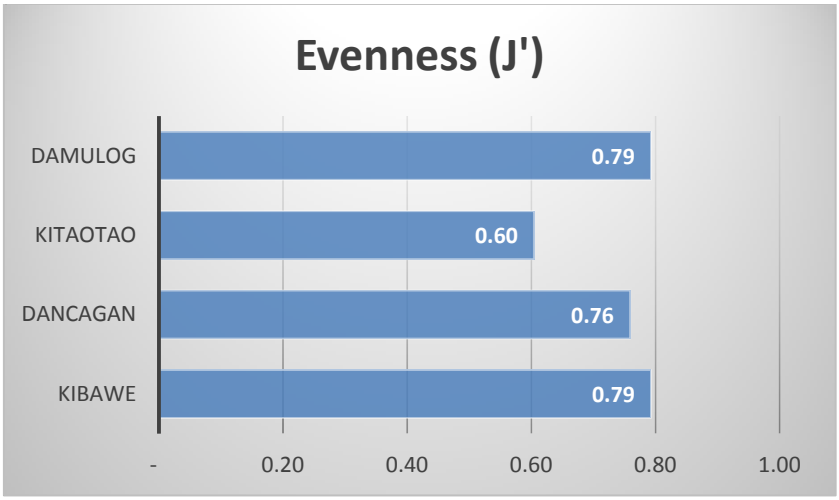


Figure 2-22: Evenness Indices of Plant Communities in the Assessed Municipalities of the Project.

2.1.4.1.5 Terrestrial Fauna

As seen in **Table 2-19**, majority of the terrestrial fauna assemblage encountered were birds with 294 individuals, 42 species and 25 families. Overall bird diversity is High at H' = 3.22 while evenness is at

Moderate at J' = 0.59. Mammals and herps, on the other hand, exhibited minimal abundance counts due to the nature of the sampling method, since traps and mist-nets were not allowed for mammals and night sampling for herps were prohibited. Results for diversity and evenness of mammals and herps were not computed due to minimal abundance counts and species richness. The checklist of terrestrial fauna species found in the assessed municipalities is shown in **Annex 5.**

Table 2-19: Summary of Results for Terrestrial Fauna

Parameters	Birds	Mammals	Herps
No. of Individuals	294	1	8
Species Richness	42	1	2
No. of Families	25	1	2
Diversity (H')	3.22	-	-
Evenness (J')	0.59	-	-

2.1.4.1.5.1 Birds

Species Abundance

A total of 294 individuals were listed for birds, the highest number of which belongs to the Pygmy Swiftlet (*Collocalia troglodytes*) at 46 individuals. Second in rank is the Short-tailed Glossy Starling (*Aplonis minor*) with 33 individuals which was only found in Kibawe Municipality, none were found in other municipalities. This species is mostly seen in man-made structures through which they build their nests and mostly are seen in groups. The Yellow Vented Bulbul (*Pycnonotus goiavier*) ranked 3rd with 24 individuals spotted and were observed in all municipalities assessed. **Table 2-20** shows the abundance of birds per Municipality.

Table 2-20: Abundance of Birds in the Assessed Municipalities of the Project

Common Name	Scientific Name	Kibawe	Dancagan	Kitaotao	Damulog	Abund
Pygmy swiftlet	*Collocalia troglodytes*	22	7	13	4	46
Short-tailed Glossy Starling	*Aplonis minor*	33				33
Yellow-vented Bulbul	*Pycnonotus goiavier*	4	8	9	3	24
Spotted Dove	*Spilopelia chinensis*	4	1	9	2	16
Zebra Dove	*Geopelia striata*	1	4	4	3	12
Asian Glossy Starling	*Aplonis panayensis*		7	5		12
Blue-throated Bee-eater	*Merops viridis*	5	2	2	2	11
Olive-backed Sunbird	*Cinnyris jugularis*		9	2		11
Common Emerald Dove	*Chalcophaps indica*	1	4	3	2	10
Barn Swallow	*Hirundo rustica*	3		3	3	9
Large-billed Crow	*Corvus macrorhynchos*	3		2	3	8
White-eared Brown Dove	*Phapitreron leucotis*	1	2	1	3	7
Buzzing Flowerpecker	*Dicaeum hypoleucum*	3	2	2		7
Pygmy Flowerpecker	*Dicaeum pygmaeum*	2	3		2	7
Pacific Swallow	*Hirundo tahitica*				7	7
Orange-bellied Flowerpecker	*Dicaeum trigonostigma*		4	2		6
Eurasian Tree sparrow	*Passer montanus*		6			6
Lesser Coucal	*Centropus bengalensis*	1	1	1	2	5
Mettalic-winged Sunbird	*Aethopyga pulcherrima*		2	3		5
Chestnut Munia	*Lonchura atricapilla*		2	3		5

Common Name	Scientific Name	Kibawe	Dancagan	Kitaotao	Damulog	Abund
White-collared Kingfisher	*Todiramphus chloris*		1	1	2	4
Pied Triller	*Lalage nigra*	2			2	4
Scaly-breasted Munia	*Lonchura punctulata*		4			4
Brahminy Kite	*Haliastur indus*	1		2		3
Java Sparrow	*Lonchura oryzivora*		1		2	3
Glossy Swiftlet	*Collocalia esculenta*	3				3
Everett's White-eye	*Zosterops everetti*		3			3
Philippine Coucal	*Centropus viridis*			1	1	2
Orange-tufted Spiderhunter	*Arachnothera flammifera*		2			2
White-breasted Wood-swallow	*Artamus leucorynchus*	2				2
Olive-capped Flowerpecker	*Dicaeum nigrilore*				2	2
Oriental Dollarbird	*Eurystomus orientalis*				2	2
Blue-tailed Bee-eater	*Merops philippinus*	2				2
Black-naped Oriole	*Oriolus chinensis*				2	2
Square-tailed Drongo Cuckoo	*Surniculus lugubris*			2		2
Spangled Drongo	*Dicrurus hottentottus*	1				1
Little Egret	*Egretta garzetta*		1			1
Brown Shrike	*Lanius cristatus*		1			1
Coppersmith Barbet	*Megalaima haemacephala*				1	1
Changeable Hawk-Eagle	*Nisaetus cirrhatus*	1				1
Pied Fantail	*Rhipidura nigritorquis*	1				1
Philippine Green Pigeon	*Treron axillaris*				1	1
Total		96	77	70	51	294

Species Richness

The highest number of species can be found in Dancagan Municipality with 23 species in total. Damulog and Kibawe Municipality both had 21 species encountered while Kitaotao exhibited the least number of species with 20. **Figure 2-23** shows the species richness of birds in the assessed municipalities.

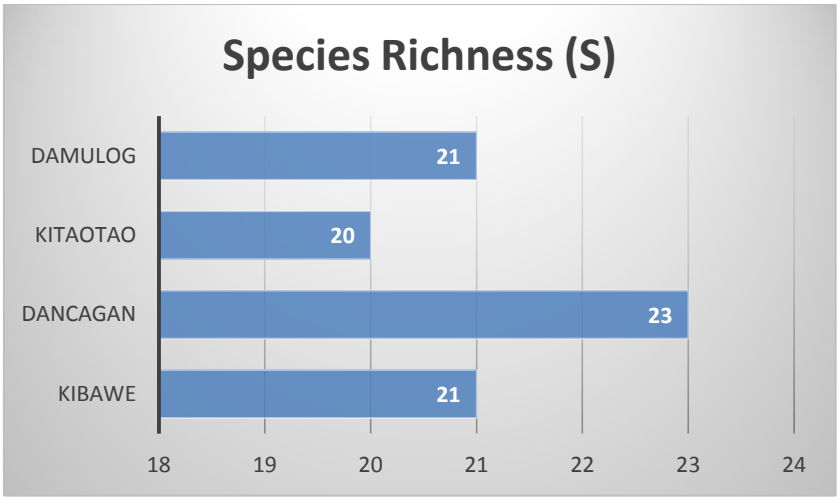


Figure 2-23: Species Richness of Birds in the Assessed Municipalities

Diversity Index (H')

From a municipal perspective, Damulog, Dancagan and Kitaotao exhibited Diversity Index values at H' = 2.93, which is considered as moderate according to the Fernando Biodiversity Scale. The Municipality of Kibawe on the other hand, exhibited Low diversity at H' = 2.26. This indicates that less bird species and number of individuals were apparent in the Municipality of Kibawe. **Figure 2-24** shows the diversity of birds in the different municipalities assessed.

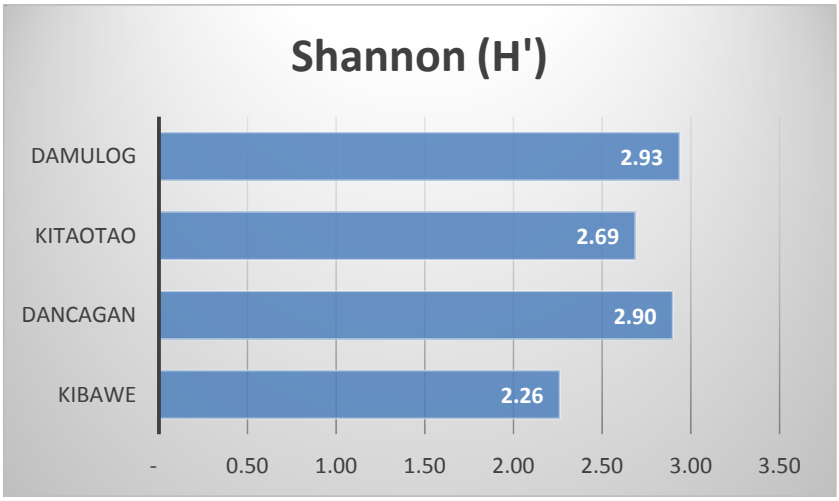


Figure 2-24: Diversity of Birds in all Assessed Municipalities.

Evenness Index (J')

Number of individuals in Damulog and Dancagan Municipalities exhibited Very High evenness at J' = 0.90 and J' = 0.79, respectively, which indicates that species do not differ in numbers compared to Kitaotao and Kibawe Municipalities. Kitaotao Municipality showed High evenness at J' = 0.73 while Kibawe showed the lowest evenness index at Moderate J' = 0.46. This indicates that bird species tend to cluster in Kibawe Municipality compared to other Municipalities assessed. **Figure 2-25** shows the evenness index values for all the municipalities assessed.

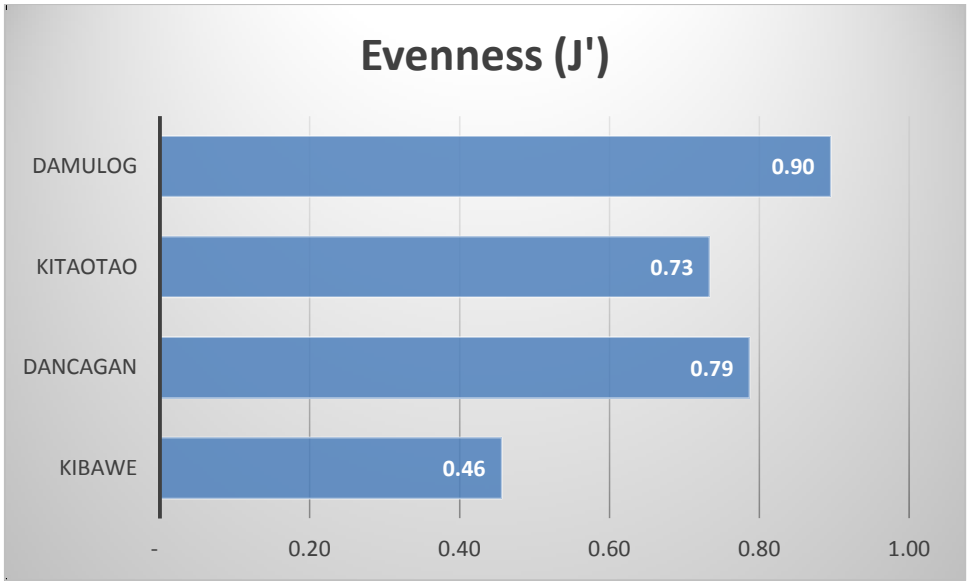


Figure 2-25: Evenness of Birds in all Assessed Municipalities.

2.1.4.1.5.2 Mammals

Only one (1) individual under 1 species was observed on-site which was the Lesser Musky Fruit Bat (*Ptenochirus minor*). This mammal belongs to the Family Pteropodidae and can only be found in the Mindanao faunal region which makes it an Endemic Species. Due to limited sightings of mammals, other parameters and diversity values were not computed.

2.1.4.1.5.3 Herps

Two species of herps were observed during the surveys which include 2 individuals of Jagor's Sphenomorphus (*Pinoyscincus jagori*) which belong to the family Scincidae and 6 individuals of the Philippine Sailfin Lizard belonging to the family Agamidae. Due to the limited number of abundance counts and species richness, diversity and evenness indices were not computed.

2.1.4.2 Historical Occurrence of Pest Infestation, Forest/Grass Fire and/or Similar Incidences

There were no records of pest infestation within the Project area despite the quarterly advisories of the Bureau of Plant and Industries. An advisory dated on the 2nd quarter of 2018 warned of the possible occurrence of rice stem borer and rice black bug in Bukidnon. For occurrences of Forest/Grassfires, on the other hand, there were also no records from the Project area. However, based on site observations, cornfields with nearby secondary forests suggest that “kaingin” is being done in the higher elevation areas. As seen in **Figure 2-26,** the proximity of cornfields to secondary forests in steep slopes suggest that kaingin is still conducted by local farmers.

Figure 2-26: Evidence of Recent Clearing in Steep Slopes of the Project Site Suggesting Kaingin Activities

2.1.4.3 Threat to existence and/or loss of important local species

2.1.4.3.1 Geographic Distribution

Endemic species are those species which can only be found in a specific island, country or region and does not occur in other places. These species are highly conserved since their populations are only confined within a geographic boundary. For Flora, some endemic species include Duguan (*Myristica philippinensis*) and Antipolo (*Artocarpus blancoi*). These species are endemic to the Philippines and are not observed in other countries.

For terrestrial fauna, endemic birds include Buzzing Flowerpecker (*Dicaeum hypoleucum*), Pygmy Flowerpecker (*Dicaeum pygmaeum*), and the Metallic-winged Sunbird (*Aethopyga pulcherrima*). One endemic mammal was also observed on-site which is the Lesser Musky Fruit Bat (*Ptenochirus minor*). **Table 2-21** shows the list of endemic species found in the assessed municipalities.

Table 2-21: List of Endemic Species observed in the Assessed Municipalities

Group	Family Name	Common Name	Scientific Name
Flora	Moraceae	Antipolo	*Artocarpus blancoi*
Flora	Myristicaceae	Duguan	*Myristica philippinensis*
Fauna	Dicaeidae	Buzzing Flowerpecker	*Dicaeum hypoleucum*
Fauna	Dicaeidae	Pygmy Flowerpecker	*Dicaeum pygmaeum*
Fauna	Nectariniidae	Mettalic-winged Sunbird	*Aethopyga pulcherrima*
Fauna	Nectariniidae	Orange-tufted Spiderhunter	*Arachnothera flammifera*
Fauna	Dicaeidae	Olive-capped Flowerpecker	*Dicaeum nigrilore*
Fauna	Columbidae	Philippine Green Pigeon	*Treron axillaris*
Fauna	Cuculidae	Philippine Coucal	*Centropus viridis*
Fauna	Rhipiduridae	Pied Fantail	*Rhipidura nigritorquis*
Fauna	Apodidae	Pygmy swiftlet	*Collocalia troglodytes*
Fauna	Pteropodidae	Lesser Musky Fruit Bat	*Ptenochirus minor*

2.1.4.3.2 Conservation Status

Species with conservation importance were found in the dam areas and vicinities. Molave (*Vitex parviflora*) is classified as Endangered, based on DAO 2017-11 while classified as Vulnerable in IUCN (2018-01). Mahogany (*Swietenia mahagoni)* was also classified as Endangered in IUCN but was not

listed in DAO 2017-11. Vulnerable species on the other hand include Pahutan (*Mangifera altissima*), Narra (*Pterocarpus indicus*) and Dao (*Dracontomelon dao*). Duguan (*Myristica philippinensis*) is listed as Other Threatened Species in DAO 2017-11. For Fauna, 2 species were found to be globally important and include the Java sparrow for birds and the Philippine Sailfin Lizard for Herps. Both were listed as vulnerable in IUCN (2018). **Table 2-22** shows the list of threatened flora and fauna species in the assessed municipalities.

Table 2-22: List of Locally and Globally Threatened Species found in the Assessed Municipalities

Family Name	Scientific Name	Common Name	Conservation Status	
			DAO 2017-11	IUCN 2018-01
Terrestrial Flora				
Verbenaceae	*Vitex parviflora*	Molave	Endangered	Vulnerable
Meliaceae	*Swietenia mahagoni*	Mahogany	Not Listed	Endangered
Moraceae	*Artocarpus blancoi*	Antipolo	Not Listed	Vulnerable
Anacardiaceae	*Mangifera altissima*	Pahutan	Vulnerable	Vulnerable
Fabaceae	*Pterocarpus indicus*	Narra	Vulnerable	Vulnerable
Anacardiaceae	*Dracontomelon dao*	Dao	Vulnerable	-
Myristicaceae	*Myristica philippinensis*	Duguan	Other Threatened Species	-
Terrestrial Fauna				
Estrildidae	*Lonchura oryzivora*	Java Sparrow	-	Vulnerable
Agamidae	*Hydrosaurus pustulatus*	Philippine Sailfin Lizard	-	Vulnerable

2.1.4.4 Threat to Abundance, Frequency and Distribution of Important Species

2.1.4.4.1 Importance Value

2.1.4.4.1.1 Terrestrial Flora

Ranked 1st is the Saging Saba (*Musa paradisiaca*) which was observed in all the municipalities assessed, then followed by Corn (*Zea mays*) in 2nd which are all cultivated crops and indicative of the dominant vegetation in the Project area. Next in rank are the Niog (*Cocos nucifera*) and Tan-ag (*Kleinhovia hospita*) which are trees especially adaptive to sun-light and are usually found near cultivated lands. Buyo-buyo (*Piper aduncum*) is ranked 5th for importance value. This species is considered as an invasive alien species (IAS) which cover vast tracts of lands and has the potential of taking over lands due to its prolific seeding and adaptability. Other species ranked for importance value include Papaya (*Carica papaya*), Madre-cacao (*Gliricida sepium*), Saging (*Musa sp.*), Gonoy (*Chromolaena odorata*) and Cavendish (*Musa sp.*). Computations for the IV of Terrestrial Flora species are found in **Table 2-23.**

Table 2-23: Top Ranked Species as computed for Importance Value.

Family Name	Common Name	Scientific Name	Abund	Rabund	Freq	Rfreq	IV
Musaceae	Saging saba	*Musa paradisiaca*	248	17.55	0.75	6.47	12.01
Poaceae	Corn/mais	*Zea mays*	300	21.23	0.25	2.16	11.69
Arecaceae	Niog	*Cocos nucifera* L.	96	6.79	0.58	5.04	5.92
Malvaceae	Tan-ag	*Kleinhovia hospita* L.	51	3.61	0.42	3.60	3.60
Piperaceae	Buyo-buyo	*Piper aduncum*	43	3.04	0.33	2.88	2.96

Family Name	Common Name	Scientific Name	Abund	Rabund	Freq	Rfreq	IV
Caricaceae	Papaya	*Carica papaya* L.	16	1.13	0.5	4.32	2.72
Fabaceae	Madre-cacao	*Gliricida sepium* (Jacq.) HBK.	20	1.42	0.42	3.60	2.51
Musaceae	Saging	*Musa* sp.	52	3.68	0.08	0.72	2.20
Asteraceae	Gonoy	*Chromolaena odorata* (L.) R.M.King & M. Robinson	51	3.61	0.08	0.72	2.16
Musaceae	Cavendish	*Musa* sp.	51	3.61	0.08	0.72	2.16

2.1.4.4.1.2 Terrestrial Fauna

The top-ranked bird species belong to the Pygmy Swiftlet (*Collocalia troglodytes*) which had double that of the abundance of the Yellow-vented Bulbul (*Pycnonotus goiavier*) even if both species were found in all the municipalities assessed. Ranked 3rd is the Short-tailed Glossy Starling which exhibited higher abundance value but were only seen in one municipality throughout the survey. Other top-ranked species include Spotted Dove (*Spilopelia chinensis*), Zebra Dove (*Geopelia striata*). Blue-throated Bee-eater (*Merops viridis*), Common Emerald Dove (*Chalcophaps indica*), White-eared Brown Dove (*Phapitreron leucotis*), Barn Swallow (*Hirundo rustica*) and the Asian Glossy Starling (*Aplonis panayensis*). **Table 2-24** shows the top-ranked species based on their Importance Values. **Annex 5** shows the computations of IV for Terrestrial Fauna.

Table 2-24: Top-Ranked Bird Species based on their Importance Value.

Common Name	Scientific Name	Abund	Rabund	Freq	Rfreq	IV
Pygmy swiftlet	*Collocalia troglodytes*	46	15.65	1.00	4.71	10.18
Yellow-vented Bulbul	*Pycnonotus goiavier*	24	8.16	1.00	4.71	6.43
Short-tailed Glossy Starling	*Aplonis minor*	33	11.22	0.25	1.18	6.20
Spotted Dove	*Spilopelia chinensis*	16	5.44	1.00	4.71	5.07
Zebra Dove	*Geopelia striata*	12	4.08	1.00	4.71	4.39
Blue-throated Bee-eater	*Merops viridis*	11	3.74	1.00	4.71	4.22
Common Emerald Dove	*Chalcophaps indica*	10	3.40	1.00	4.71	4.05
White-eared Brown Dove	*Phapitreron leucotis*	7	2.38	1.00	4.71	3.54
Barn Swallow	*Hirundo rustica*	9	3.06	0.75	3.53	3.30
Asian Glossy Starling	*Aplonis panayensis*	12	4.08	0.50	2.35	3.22

2.1.4.4.2 Economic Importance and Uses

Since majority of the lands are cultivated, flora species found were mostly used as food sources, construction, medicinal, ornamental or used as raw materials for making different products. Species used as food sources include fruit trees such as Pahutan (*Mangifera altissima*), Durian (*Durio zibethinus*), Nangka (*Artocarpus heterophyllus*), and Guyabano (*Annona muricata*). Those species used for construction include Pahutan (*Mangifera altissima*), Antipolo (*Artocarpus blancoi*), and Niog (*Cocos Nucifera*). Some species used for medicinal purposes are Guyabano (*Annona muricata*), Bayabas (*Psidium guajava*), and Malunggai (*Moringa oleifera*). For ornamentals, same species used are Pakpak-Lawin (*Drynaria quercifolia*) and Ilang-ilang (*Cananga odorata*). The list of species with economic importance and uses are shown in **Table 2-25**.

Table 2-25: List of Species with Economic Importance and Uses

Family Name	Scientific Name	Common Name	Economic Importance/ Uses
Anacardiaceae	*Mangifera altissima* Blco.	Pahutan	construction, edible fruit
Bombacaceae	*Durio zibethinus* Murray	Durian	edible fruit
Moraceae	*Artocarpus heterophyllus* Lamk.	Nangka	edible fruit
Annonaceae	*Annona muricata* L.	Guyabano	edible fruit, medicinal
Myrtaceae	*Psidium guajava* L.	Bayabas	edible fruit, medicinal
Arecaceae	*Arenga pinnata* (Wurmb) Merr.	Kaong	Edible fruit, ornamental
Anacardiaceae	*Mangifera indica* L.	Mangga	edible fruit, ornamental, furniture
Musaceae	*Musa paradisiaca*	Saging saba	Food
Euphorbiaceae	*Manihot esculenta*	Cassava	Food, medicinal
Moringaceae	*Moringa oleifera* Lam.	Malunggai	food, medicine
Moraceae	*Artocarpus blancoi* (Elmer) Merr.	Antipolo	lumber, construction
Asteraceae	*Mikania cordata* (Burm.f.) B.L.Rob.	Uoko	Medicinal
Verbenaceae	*Premna odorata* Blco.	Alagau	Medicinal
Mimosaceae	*Mimosa pudica* L.	Makahiya	Medicinal, forage
Arecaceae	*Cocos nucifera* L.	Niog	Medicine, food, cottage, construction
Polypodiaceae	*Drynaria quercifolia* (L.) J. Sm.	Pakpak-lawin	Ornamental
Annonaceae	*Cananga odorata* (Lamk.) Hook. f. & Thoms.	Ilang-ilang	ornamental, medicinal,essential oil
Mimosaceae	*Paraserianthes falcataria* (L.) Nielsen	Moluccan sau	pulp and paper
Araliaceae	*Polyscias nodosa* (Blume) Seem	Malapapaya	Toothpick, bakya
Malvaceae	*Kleinhovia hospita* L.	Tan-ag	wooden shoes, edible leaves

2.1.4.5 Hindrance to Wildlife Access

As seen in the Land Cover Map in **Figure 2-16**, majority of the lands are mostly cultivated lands with grasslands and plantations. Forest fragmentation will not be experienced since most of the areas are cultivated lands and no forests will be affected by the inundation of the rivers. Thus, there will be minimal hindrance to wildlife access in the project area.

Constructing the Dam itself will act as a barrier which will separate those lands in the upstream areas of the riverine ecosystem and the downstream areas. Non-volant mammals most especially would be affected as this will become a hindrance to their access from downstream to upstream or vice versa where their food sources may be located. Nonetheless, those areas near the dams will have an increase in security and protection which in turn will not be affected by land cultivation due to the dam itself. The lands near the dam can recover into forestlands where terrestrial fauna can thrive.

2.1.4.6 Environmental Impacts of Project Activities

Construction of the dam would entail transport of raw materials in to the site. The proposed route in transporting raw materials should be followed to minimize unnecessary clearing of vegetation in the area. However, if vegetation clearing is required, species listed in the IUCN Red List should be avoided as much as possible. Tree-cutting permits should be acquired before the cutting of trees shall be implemented.

Once the dam is completed, it may create a pool as it accumulates water. Drowned vegetation should be minimized by limiting the height of the dam based on the proposed height. This prevents

unnecessary submergence of vegetation. Also, the dam may become a barrier or a hindrance to fish species downstream which are essential food sources for some birds such as the kingfishers. This may cause an imbalance within the habitat which may either increase or decrease faunal populations.

The noise generated by vehicles may cause disturbance to birds, mammals and herps. This may in turn cause the faunal populations within the area to decrease temporarily until the dam is completed.

It must be ensured that fish from one side of the dam gain access to the other side of the dam. The dam may become a barrier or a hindrance to fish species which are essential food sources for some birds such as the kingfishers. This may cause an imbalance within the habitat which may either increase or decrease faunal populations.

2.1.4.6.1 GHG Emissions and Possible Sequestration Programs

Most of the green house gas emissions will be emitted by herbs and shrubs due to vegetative clearing and inundation of reservoir. Carbon stocks from trees, where majority of carbon is stored, released to the atmosphere will be minimal since most of the lands are agricultural farms and not forestlands.

In total, the terrestrial flora assessment generated 2 species which are endemic or can only be found in the Philippines. These are mostly tree species which grow into large individuals through which the potential for carbon storage is maximized through their carbon sequestration and storage. Other endemic species not observed on-site but where sighted through previous assessment (BSI, 2017) include Katmon Kalabaw (*Dillenia reifferscheidia*), Binungang ipot (*Areca ipot*), and Lago (*Prunus grisea*).

Threatened species on the other hand were also observed in the area during the assessment which includes Molave (*Vitex parviflora*), Pahutan (*Mangifera* altissima) and Dao (*Dracontomelon dao)*. These species are classified based on IUCN 2018-01 and DAO 2017-11. These species grow into large diameter trees wherein they sequester carbon and store the carbon into their trunks.

It is recommended that endemic fruit bearing trees be considered in the Sequestration Programs and planted in the river banks of the inundated areas to improve feeding areas for birds, herps and mammals. Increased security and protection on the areas will enable the lands near the dam and inundated areas to recover into forestlands where Flora and Fauna diversity can increase. Suggested species for the sequestration programs include Pahutan (*Manggifera altissima*), Duhat (*Syzygium cumini*) and Bangkoro (*Morinda citrifolia*).

Threats to the existence of these species are loss of habitat and disturbances brought about by the project such as vegetation clearing, reservoir establishment, and faunal displacement. In order to mitigate the impacts of these threats, all trees to be cut and felled should follow DENR Memorandum Order 2012-02 where 1 cut or relocated tree should be replaced by 100 trees. This ensures that regeneration of flora species and the return of disturbed fauna species are hastened. It is recommended that the endemic, keystone and globally important flora species be used in the rehabilitation efforts to prevent alteration of the original species composition in the area.

Flora species threatened to be submerged upstream are those tree species with the least relative abundance and density values. Since these species have the least populations in the area, they are the easiest to disappear on-site. On the reservoir area, species with the least number is *Shorea contorta.* This species are from the Dipterocarpaceae family, known to have high quality wood and are used for construction purposes. To mitigate the impacts of the Project, this species may be used for rehabilitation of degraded lands. These are trees with high capacity to store carbon which may help mitigate the effects of GHGs and can be included in carbon sequestration programs.

2.1.4.7 Indicative Watershed Management

The project is located in the Municipalities of Dangcagan, Damulog, Kibawe, and Kitaotao, all in the Province of Bukidnon. The dam and power house are located in the Pulangi River within Damulog Municipality with a reservoir area of 2,924.00 ha which covers up to the Municipalities of Dangcagan, Kibawe and Kitatao, all in the Province of Bukidnon. As shown in **Figure 2-27**, the headwaters of Pulangi River stretch upstream to Mts. Amaloi, Kitanglad, and Kalatungan. However, for this Project, the watersheds to be managed will only be those inside the affected Municipalities.

2.1.4.7.1 Watershed Management Plan

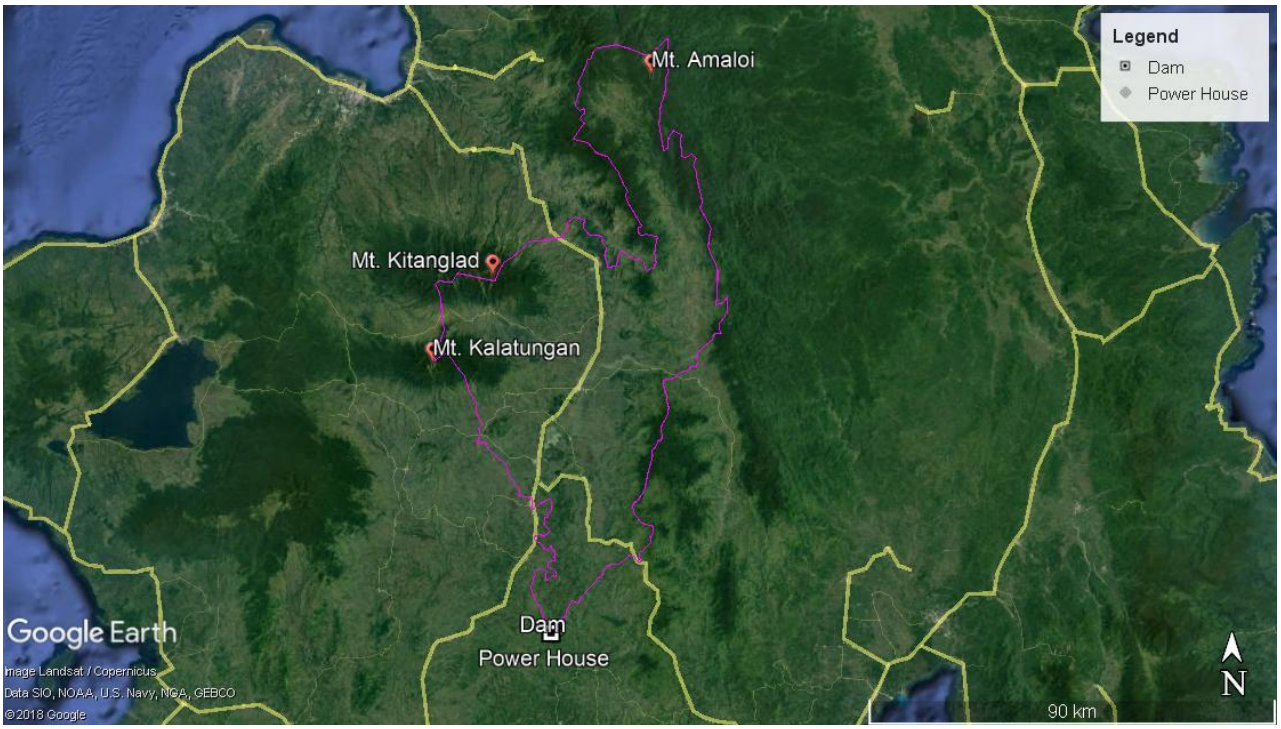
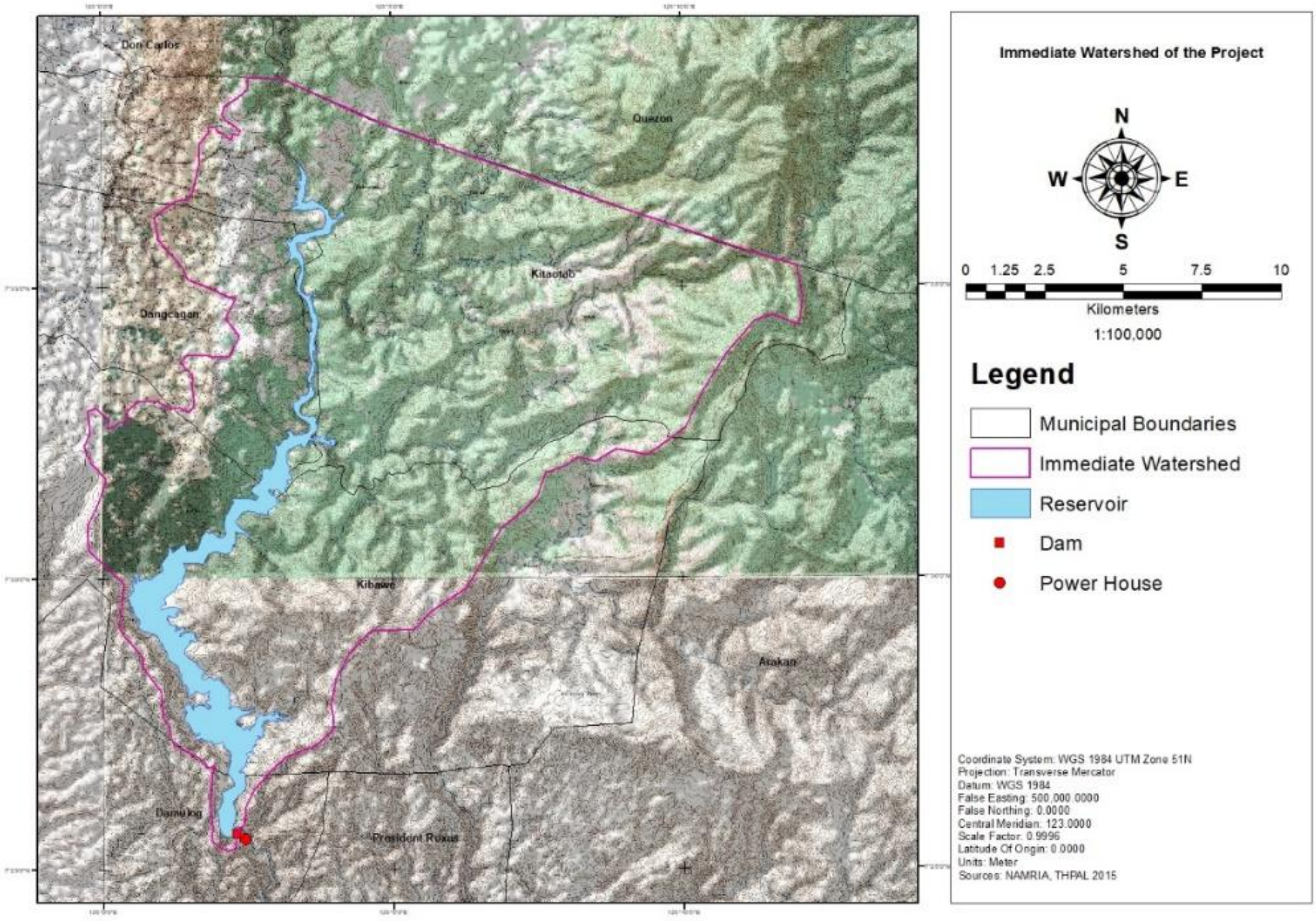


Figure 2-27: Location of headwaters of Pulangi River,

The delineated watershed spans to an area of 26,200.82 ha covering the affected municipalities. Vegetation is described as dominated by agricultural lands with patches of shrublands and grasslands with presence of open forests located at mountain tops. Highest elevation is at 688 masl in Kibawe Municipality. The delineation of the immediate watershed within the affected municipalities is shown in **Figure 2-28.**



Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

Immediate Watershed Covering the Project

FIGURE NO.:

2-28

To minimize problems in flood and soil erosion, reforestation projects within the watershed must be given a priority. Other strategies in managing the watershed is to preserve and develop potential tourist areas/spots, to improve roads and communication facilities, to establish green belt areas, sustainable implementation of plans and program for the watershed and strict enforcement/ implementation of laws and ordinances that regulates the cutting of trees. Moreover, establishments of sites for eco-park, MRF, composting center, eco garden and construction of road improvements, gutters and drainage canal in the must also be done.

Farmers in the watershed area should also adopt improved technologies (Integrated Pest Management - IPM) and sustainable indigenous practices that are less destructive to the environment, at the same time can produce maximum yield capacity of the land is one of the strategies for the economic management of the area. Development of potential areas suited for economic management industry in the relocation sites must be prioritized. Also, the involvement and leadership of the community in terms of planning and implementing possible projects and programs will endow to have a sustainable development of the people and the area. Management and strategies for watershed management are listed as follows:

2.1.4.7.2 Strategies and Development on Environmental Management

- Preservation and development of potential tourist areas/spots
- Improvement of roads and communication facilities
- Enough areas for the establishment of green belt areas
- Sustain the implementation of plans and program for the proclamation of watershed and protected areas.
- Strict enforcement and implementation of laws and ordinances to regulate the cutting of trees.
- Acquire site for eco-park, MRF, composting center and eco garden
- Construct road side gutters and drainage canal in the Poblacion.

A. Water Resources:

- Construction of rainwater harvesting structures to impound rainwater
- Provision of water, wastewater and sewage treatment facilities
- IEC Campaign
- Provide support to Water Districts to improve service

B. Watershed Management:

- Improve protection of water resources
- Mainstream climate change adaptation
- Conduct of IEC to create public awareness on forest laws and regulations
- Conduct of IEC and MES to create public awareness on appropriate upland farming practices
- Capacity development for regulators (eg. Forest guards)
- Encourage private participation (Bantay Gubat, bantay Watershed)
- Establishment of nurseries to accommodate demand for planting materials
- Use of Indigenous and endemic species for re-vegetation and engineering measures to control erosion and slope
- protection

- Soil and water conservation through reforestation, agro-forestation and other vegetative measures
- Improvement of upland farming practices such as SALT (Sloping Agricultural Land Technology), terracing and others.

C. Flood Mitigation and Hazards Management

- Forest protection
- Conduct vulnerability assessment on the watersheds
- Flood warning system
- Improvement/rehabilitation of drainage system
- Adoption of engineering measures to control landslides, flooding and severe erosion
- Capacity building of LGUs
- Improvement of information system

D. Biodiversity Conservation:

- Strict enforcement of wildlife laws and regulations
- Inventory of flora and fauna
- Monitoring of flora and fauna
- Enhance implementation of laws on Biodiversity Conservation

2.1.4.7.3 Strategies on Economic Development

- Development and installation of sustainable municipal wide irrigation system by constructing additional irrigation facilities and rehabilitation of existing irrigation system
- Improvement of farm to market roads.
- Regulation of local transport fare rates and freight charges.
- Develop scheme to promote more seed producers and to produce rice seeds before planting season. Establish and support rice seed growers
- Promote simultaneous planting activity.
- Develop new financial assistance programs.
- Promote diversified crop production to maximize productivity of farmers
- Encourage farmers to adopt improved technologies and encourage the practice Integrated Pest Management; provide livelihood and other alternative source of income to farmers; Provide/facilitate availment of low interest financing for farmers
- Linkage and lobbying to national government agencies such as Department of Agriculture (DA), Department of Land Reform (DLR), Department of Public Works and Highways for the construction of proposed infra-support facilities such as irrigation, post-harvest facilities and farm to market roads
- Implementation of zoning rules that protect watersheds
- Facilitate technology transfer specifically on integrated pest management and other agricultural technology that uses organic inputs.

2.1.4.7.4 Strategies and Development on Solid Waste Management

A. Waste Disposal

- Improve the waste collection and disposal system by educating the residents on proper and sanitary management and disposal of wastes
- Allocation of funds to acquire lot for landfill as a permanent dumpsite
- Purchase modern garbage collector trucks and facilities and additional equipment for garbage collection
- Enactment of ordinances and the enforcement of laws relative to watershed protection and conservation.

B. Drainage/Sewerage

- Construct road side gutters and drainage canals

Prioritize in the utilization of development fund the construction of a viable drainage system

2.2 Water

2.2.1 Hydrology

2.2.1.1 Available Data and Information

2.2.1.1.1 General

During its lifetime, a dam is exposed to different weather loads. The dam is affected by weather loads such as wind and hydrological load caused by precipitation. Collection of hydrometric data is critical to the understanding of the extreme events that may affect the structure. Historic hydrometric data provides the basis for understanding the potential risk and hazard that may subject the dam and its attendant structures.

Hydro-meteorological data were obtained from government agencies such as PAGASA and DPWH-BRS while topographic maps are obtained from NAMRIA. The data collected include daily rainfall and daily streamflow data recorded at various stations within and in the vicinity of the project study area.

2.2.1.1.2 Available Data

The various rainfall and gauging stations near the proposed project site are shown in **Figure 2-29.**

Figure 2-29: Rainfall and Gauging Stations near the Proposed Project Site

2.2.1.1.2.1 Rainfall Data and Climatological Data

The nearest rainfall station within the project site with reliable and considerable length of records is situated in Malaybalay, Bukidnon. The nearest synoptic stations of interest are at Malaybalay, Davao, Tagum, Hinatuan, Cotabato and Butuan.

The specific locations of the nearest synoptic station and adjacent rainfall stations including period of available maximum daily rainfall records are summarized in **Table 2-26.**

Table 2-26: Location Coordinates and Length of Available Records in Rainfall Stations near the Project Area

Station	Location	Coordinates		Available Record	
		N Latitude	E Longitude	Max 24-hr Rainfall	RIDF
Davao	Davao City	7° 07' 40.41"	125° 39' 17.43"	1949-2017	51 yrs
Tagum	Davao del Norte	7° 20' 48.00"	125° 43' 30.00"	1977-2016	42 yrs
Malaybalay	Bukidnon	8°0 9' 07.30"	125° 07' 57.10"	1957-2016	31 yrs
Hinatuan	Surigao del Sur	8° 22' 12.00"	125° 20' 12.00"	1951-2017	
Butuan	Agusan del Norte	8° 56' 49.17"	125° 28' 56.76"	1981-2014	21 yrs
Cotabato	Cotabato City	7° 09' 42.22"	124° 12' 46.91"	1988-2016	

2.2.1.1.2.2 Streamflow Data

Streamflow data at Pulangi IV and Tumaras gaging stations including the derived monthly streamflow at Pulangi V were collected from reports and publications. Summary statistics of the monthly streamflow at Pulangi IV, Tumaras gaging station and Pulangi V are presented in **Table 2-27**, **Table 2-28** and **Table 2-29**, respectively. The mean monthly streamflow at Pulangi V dam site is 186 cms.

Table 2-27: Summary of Monthly Streamflow at Pulangi IV (1964-1994), cms

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Volume, MCM	Mean
Mean	120	119	96	78	182	156	160	151	151	154	134	115	4040	128
Max	243	216	210	150	247	316	285	298	280	269	274	176	5417	171
Min	51	41	40	33	40	68	108	72	67	65	69	51	2549	81
Max-Min	192	178	170	117	207	248	177	226	213	205	205	125	2869	91
Std Dev	44.36	43.77	42.16	32.99	47.07	61.45	42.31	52.98	54.09	49.59	46.91	30.92	725.05	23
Cv	0.37	0.37	0.44	0.43	0.46	0.39	0.27	0.35	0.36	0.32	0.35	0.27	0.18	0.18

Table 2-28: Summary of Monthly Streamflow at Tumaras Gaging Station (1989-1995), cms

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Volume, MCM	Mean
Mean	167	157	131	117	163	228	251	243	253	260	174	180	6210	197
Max	255	246	202	185	244	370	356	330	466	434	260	345	8852	280.7
Min	100	84	79	76	83	127	173	135	93	116	127	101	4140	131
Max-Min	155	162	123	109	161	243	183	195	373	318	133	244	4712	149.7
Std Dev	50	51	48	43	66	97	62	72	129	101	44	88	1587	50
Cv	0.3	0.32	0.37	0.37	0.4	0.42	0.25	0.29	0.51	0.39	0.25	0.49	0.26	0.26

Table 2-29: Derived Summary of Monthly Streamflow at Pulangi V (1964-1994), cms

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Volume, MCM	Mean
Mean	174	172	144	123	155	222	226	215	213	221	194	168	5860	186
Max	328	263	287	213	333	419	380	397	374	361	367	239	7569	239
Min	95	80	75	72	77	113	165	116	88	110	119	96	3933	124
Max-Min	233	183	213	141	257	306	215	280	296	251	248	144	3636	115
Std Dev	55	51	50	42	59	77	54	66	88	63	56	37	910	29
Cv	0.32	0.3	0.36	0.34	0.38	0.35	0.24	0.31	0.32	0.29	0.29	0.22	0.16	0.16

2.2.1.1.2.3 Design Floods

Design flood data were collected from previous feasibility study reports. Design floods are the main parameters in the design of project spillway and to the design of river diversion facilities. Table 2-30 shows the design floods at various return periods.

Table 2-30: Design Floods (cms)

Return Period (years)	10	20	50	100	1000	10000	PMF
Peak Discharge (cms)	2,100	2,556	3,155	3,700	5,700	8,400	11,300

2.2.1.1.3 Normal Climatological Data

Climatological normal data for the period 1980-2010 were obtained at PAGASA for its synoptic station located in Malaybalay City. The data is summarized as shown in **Table 2-31** below.

Table 2-31: Climatological Normals, Malaybalay City

Month	Rainfall		Temperature						Vapor	Rel.	Wind		Number of Days w/	
	Amount	Number of Rainy	Max	Min	Mean	Dry Bulb	Wet Bulb	Dew Pt.	Pressure	Hum.	Direction	Speed	Thunder-storm	Light-ning
	(mm)	Days	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(mbs)	%	(16 pt)	(mps)		
Jan	142.5	16	29.0	17.9	23.5	23.0	21.2	20.4	23.9	85	S	1.0	1	1
Feb	106.1	13	29.4	17.6	23.5	23.1	21.2	20.4	23.9	84	E	1.0	2	1
Mar	112.5	13	30.6	17.6	24.1	23.9	21.5	20.5	24.0	81	S	1.0	3	2
Apr	115.6	12	31.7	18.1	24.9	24.6	22.0	20.9	24.6	80	S	1.0	6	6
May	224.8	18	31.2	19.1	25.2	24.9	22.7	21.8	26.1	83	S	1.0	14	11
Jun	313.5	23	29.8	19.2	24.5	24.1	22.4	21.7	25.9	86	S	1.0	13	9
Jul	323.3	24	29.0	18.9	24.0	23.6	22.1	21.5	25.6	88	S	1.0	14	9
Aug	294.4	22	29.1	18.8	24.0	23.5	22.0	21.4	25.4	88	S	1.0	13	9
Sep	315.7	24	29.5	18.7	24.1	23.6	22.1	21.5	25.6	88	S	1.0	15	10
Oct	314.7	23	29.6	18.9	24.3	23.7	22.2	21.6	25.7	88	S	1.0	15	11
Nov	176.1	18	30.0	18.6	24.3	23.8	22.1	21.4	25.4	86	S	1.0	7	7
Dec	130.7	16	29.5	18.3	23.9	23.5	21.6	20.8	24.5	85	S	1.0	3	4
Annual	**2569.9**	**222**	**29.9**	**18.5**	**24.2**	**23.8**	**21.9**	**21.2**	**25.1**	**85**	**N**	**2.0**	**106**	**80**

2.2.1.1.4 Extreme Climatological Data

The climatological extremes as of 2017 for Malaybalay City station are given as follows:

Table 2-32: Climatological Extremes, Malaybalay City

Month	Temperature (°C)		Greatest Daily Rainfall Amount	Highest Wind (mps)		Sea Level Pressure (mbs)	
	High	Low	mm	Speed	Direction	High	Low
Jan	34.0	11.7	140.6	22	NE	1020.5	987.0
Feb	35.2	10.0	109.2	19	NE	1019.4	998.1
Mar	35.5	12.0	170.6	14	NE	1019.6	998.9
Apr	36.4	12.5	184.2	21	NW	1019.2	996.6
May	36.2	14.0	126.3	18	WNW	1019.9	997.9
Jun	34.5	13.0	130.4	18	N	1019.6	999.4
Jul	33.0	14.0	135.4	15	S	1015.3	997.4
Aug	33.5	15.0	113.6	22	SW	1016.2	998.0
Sep	34.0	15.3	128.6	18	NW	1015.9	998.6
Oct	34.0	14.9	195.9	20	N	1016.3	960.6
Nov	34.8	13.1	144.8	19	SW	1015.9	996.1
Dec	33.6	12.5	112.4	14	NE	1017.4	998.2
ANNUAL	36.4	10.0	195.9	22.0	NNW	1020.5	960.6
Period of Record	1949 -2017		1952-2017	1966 - 2017		1949 - 2017	

2.2.1.1.5 Topographic Maps

Topographic map (scale 1:50,000) for the dam site had been secured from the National Mapping and Resource Information (NAMRIA). Hydrologic parameters were based on the NAMRIA map.

2.2.1.1.6 Field Reconnaissance

Site reconnaissance survey and investigation of the proposed hydropower Pulangui V dam site was conducted on 21-22 August 2018 to assess the general features of the sites and to identify any potential problems that could affect the project sites.

The purpose of this field survey in addition to obtaining supplemental data is to:

- visually acquaint the Consultant's with conditions and constraints in the project sites.
- collect hydrologic data and verify data obtained from other sources
- identify existing features which may affect the use of surface water
- review contributing watershed characteristics and present land use
- obtain historical flood and other stream flow information
- descriptive photographs of site

2.2.1.1.6.1 Project Components

The pertinent data of South Pulangi dam and its appurtenant structures is summarized in **Table 2-33.**

Table 2-33: Pertinent Data of South Pulangi Hydroelectric Plant

	Description	Unit	Value
	Drainage Area above Damsite	km^2	3930
	Used Hydrologic Series	years	466
	Mean Annual Runoff	m^3	4.86B
	Representative Discharge	m3/s	
	Mean Annual Discharge	m^3/s	154
	Measured Maximum Discharge	m^3/s	1478
	Designed Flood Discharge (P=0.2%), (original FS)	m^3/s	5164
	Check Flood Discharge (P=0.01%), (original FS)	m^3/s	8392
	Design Discharge (Q)	m^3/s	295.5
	Construction Diversion Discharge (P=5%)	m^3/s	2556
Reservoir	Surface Area at Normal Storage Level	km^2	29.24
	Check Flood Level (p=0.01%)	masl	169.37
	Design Flood Level (p=0.2%)	masl	163.95
	Normal Storage Level	masl	165.00
	Dead Water Level	masl	135.00
	Storage Capacity Under Normal Storage Level	10^6m^3	1169.30
	Regulation Capacity	10^6m^3	674.70
	Dead Capacity	10^6m^3	494.60
Dam and Spillway	Concrete Face Rockfill Dam		
	Height	m	143
	Crest Length	m	878.5
	Concrete Spillway		
	Elevation of Weir Crest	m	149
	Length	m	160
	Number of Radial Gates	number	3
	Apperture Dimension of Water Release Sluice	m	16x16
Headworks/Intake	Overall Width	m	55.5
	Height	m	55
	Elevation of Inlet Bottom Sill	masl	118.5
	Trash Bays	number	3
	Width	m	8.5
	Height	m	16.5
	Gate	m	1
	Width	m	10
	Height	m	10
Headrace Tunnel	Circular Concrete-lined		
	Diameter	m	8
	Length	m	59
Powerhouse	Ground Type		
	Steel Penstock	number	3
	Size	m	8
	Length	m	563
	Turbine- Vertical Francis	number	3
	Capacity	MW	250

Using ICOLD definition of a large dam, the South Pulangi HEPP is considered a large dam with a height of more than 15 m and impounding more than 3.0 Mm^3.

2.2.1.2 Project Area Setting

2.2.1.2.1 Location

The South Pulangi Hydroelectric Plant is located in the island of Mindanao, specifically in the province of Bukidnon. The province belongs to Region X or Northern Mindanao comprising of the provinces of Bukidnon, Camiguin, Lanao del Norte, Misamis Occidental and Misamis Oriental (**Figure 2-30**). The region is located in the central northern part of the island of Mindanao.

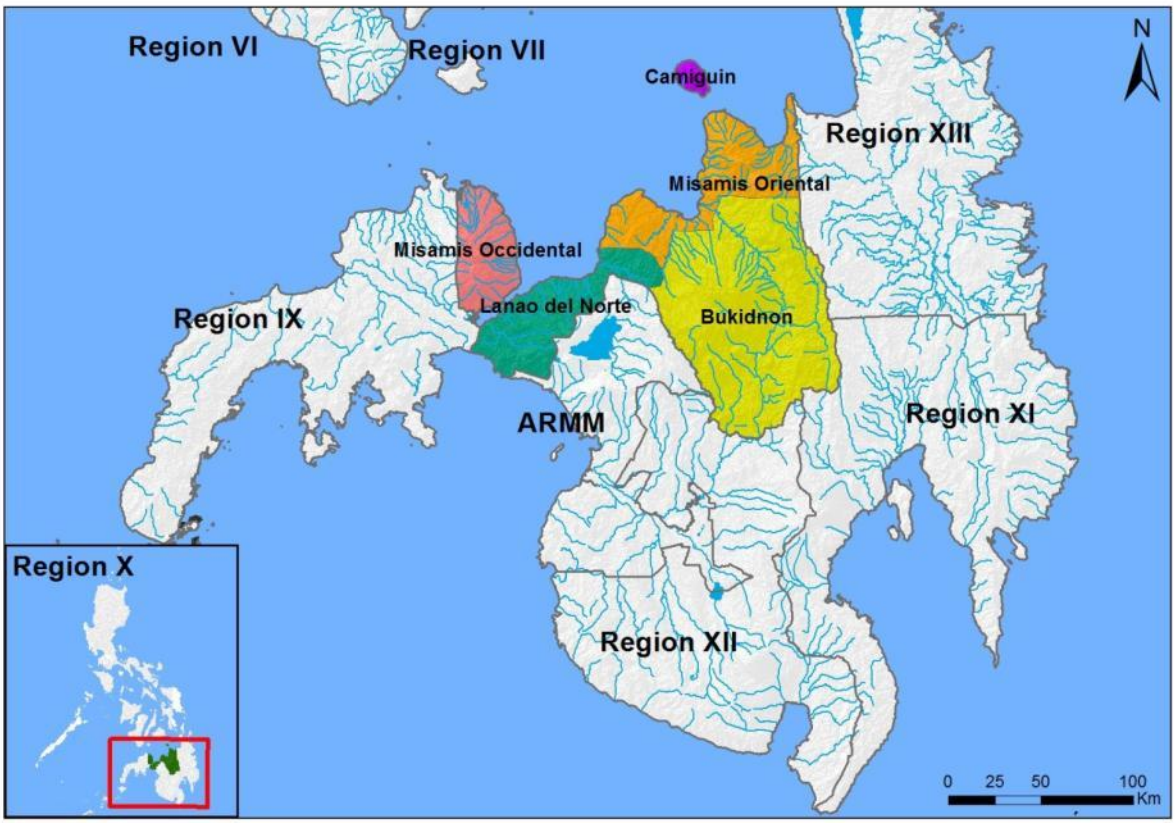


Figure 2-30: Region X- Northern Mindanao

The Province of Bukidnon is a landlocked plateau and it is bounded on the north by Misamis Oriental; on the south by North Cotabato and Davao City; on the east by Agusan del Sur and Davao del Norte; and west by Lanao del Sur. It lies between parallels 7°25' and 8°38' North latitude and meridians 124°03' and 125°16' East longitude. Malaybalay City, is the capital town. The province's total land area is 8,293.78 sq. km and accounts for 59 percent (59%) of Northern Mindanao.

Bukidnon is generally characterised as an extensive plateau but the southern and eastern boundaries are mountainous area. The province's average elevation is 915 m above sea level. The slope gradient peaks at 2,938 meters with Mt. Kitanglad, an extinct volcano occupying the central portion. Gently rolling grassland plateau cut deep and wide canyons of the Cagayan, Pulangi, and Tagoloan Rivers and their tributaries which cover a greater part of the province. The whole eastern and southern border adjoining the provinces of Agusan, Davao del Norte, and Cotabato are covered by lofty and densely forested mountains of the Pantaron Mountain Range (Central Cordillera). The Bukidnon plateau is mainly of volcanic zone consisting of pyroclastic, basaltic and andesitic cones.

The Central Cordillera is a mountain range of sedimentary, metamorphic and igneous rocks. About 49% of the land resource of the province is of rugged hills and mountains and 33% of undulating to

rolling terrain. The rest of the province is composed of nearly level terraces, alluvial lowland, canyons and gorges.

2.2.1.2.2 Project area

The dam site is located across Pulangi River at coordinates 7˚ 25' 36.84" N and 125˚ 02' 17.96" E in Barangay Tangkulan in the Municipality of Damulog, Province of Bukidnon (**Plate 2-1**).

Plate 2-1: Pulangi River at Dam Site Looking Downstream

The watershed at the dam site is elongated and oriented northeast to southwest. The area is typified by moderate to high relief with elevations ranging from 320 to 1,900 m. The most prominent ridge on the eastern part of the watershed is Mt. Sumagaya, in Claveria, Misamis Oriental with a height of 2,072 m.

The watershed encompasses approximately 3,930 sq km reckoned at the proposed dam site. The topography of the basin above the project site is predominantly rugged and mountainous.

The dam site is located in the southeastern part of Damulog municipality. Damulog is one of the 22 political subdivisions of the province of Bukidnon. Located at the southern part of the province, it is a land locked municipality bounded north-eastern by the Municipality of Kibawe; on the north-western by the Municipality of Kadingilan; and on the south by the Province of North Cotabato. It is approximately 75 km south of Malaybalay City.

2.2.1.2.3 Air Stream

The principal air streams, which significantly affect the area, are the southwest monsoon, northeast monsoon, and Pacific trade winds. The southwest monsoon originating from the north side of the Indian Ocean affects the area during the months of May to October. During this period the distribution of rainfall is influenced by the vertical situation of shear line between the South Pacific trade and southeast monsoon. The air mass is classified as equatorial maritime and is warm and very humid. The northeast monsoon, which affects the area from October to March, is most dominant during

January and February. The North Pacific trade winds generally prevail during April and May whenever the northeast and the southwest monsoons are weak. In the Philippines, the northeast monsoon is associated with the dry season while the southwest monsoon is linked with the wet season.

2.2.1.2.4 Tropical Cyclones

A tropical cyclone is a warm core, large scale circulation of winds around a central region of low atmospheric pressure. Typhoons are tropical cyclones occurring in the western Pacific Ocean. Tropical cyclones are the most influential factors that bring considerable rainfall in the Philippines. There are three classifications of tropical cyclones, namely: depressions which have wind speed of 45 to 63 kph, storms which have wind speed of 64 to 119 kph and typhoons which have maximum speed of 120 kph or stronger. Typhoons usually occur from June to December with highest frequencies in July and August. The mean annual number of tropical cyclones that pass through the Philippine Area of Responsibility (PAR) is about 20. The cyclones originate in the region of Marianas and Caroline Islands in the Pacific Ocean usually between 125°E and 170°E. Their movements follow westerly or northwesterly course over the country and deposit substantial amount of rainfall. The most frequent disastrous typhoons generally occur during the months of October and November.

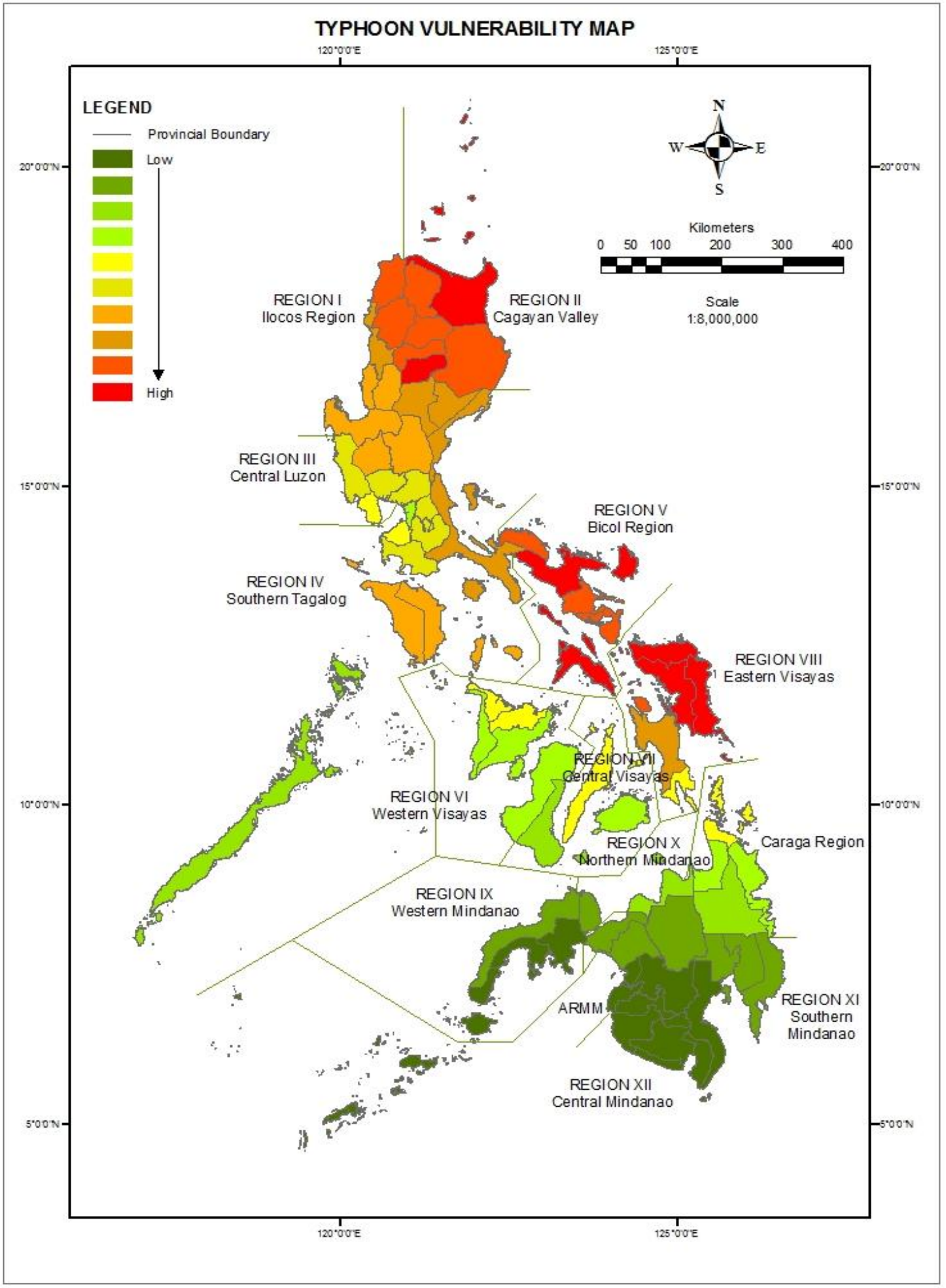
Tropical cyclones are classified according to their intensity. The World Meteorological Organization (WMO) provides the updated tropical cyclone classification:

Classification	Maximum Sustained Winds kph
Tropical depression	Up to 61
Tropical storm	61-88
Severe tropical storm	89-117
Typhoon	118 -220
Super Typhoon	Exceeding 220

Studies at selected stations in the Philippines have shown that 47% of the average yearly rainfall is due to tropical cyclones, 14% to monsoons and 39% to other weather disturbances such as thunderstorm, easterly waves, International Tropical Convergence Zone (ITCZ) and fronts.

The list of worst typhoons that affected the Mindanao Island is given below and **Figure 2-31** shows the low to medium vulnerability of the Philippine regions to typhoons.

Name	Period of Occurrence	Highest Wind Speed kph
Lucy	November 25-December 1, 1962	121
Ining *(Louise)*	November 15-20, 1964	240
Bebeng *(Sally)*	March 1-4, 1967	120
Titang *(Kate)*	October 16-23, 1970	95
Auring *(Lola)*	January 22-25, 1975	110
Bising *(Nelson)*	March 22-29, 1982	100
Nitang *(Ike)*	August 31-September 4, 1984	220
Ruping *(Mike)*	November 10-14, 1990	220
Puring *(Nell)*	December 25-28, 1993	150
Nanang *(Lingling)*	November 6-9, 2001	90
Sendong (Washi)	December 16-19, 2011	95
Pablo (*Bopha*)	December 3-6, 2012	280



Lichel Technologies, Inc.
1403 Prestige Tower Condominium,
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE:

Typhoon Vulnerability of Philippine Regions

FIGURE NO.

2-31

2.2.1.2.5 Temperature

The monthly mean, minimum and maximum temperatures (1981-2010) reckoned at Malaybalay City station is shown in **Table 2-34**.

Table 2-34: Mean, Minimum and Maximum Temperatures

Temperature,°C	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Maximum	29.0	29.4	30.6	31.7	31.2	29.8	29.0	29.1	29.5	29.6	30.0	29.5
Minimum	17.9	17.6	17.6	18.1	19.1	19.2	18.9	18.8	18.7	18.9	18.6	18.3
Mean	23.5	23.5	24.1	24.9	25.2	24.5	24.0	24.0	24.1	24.3	24.3	23.9

Source: PAGASA (1981-2010)

The mean annual temperature varies from 23.5°C to 25.2°C. February is the coldest month with monthly minimum of 17.6 °C while April is the warmest at 31.7 °C.

2.2.1.2.6 Relative Humidity

The average annual relative humidity for the project area estimated from Malaybalay station is about 85%. The mean monthly values of the relative humidity range from 80% to 88.0 percent. The most humid months usually occur during July to October while the month of April is the least humid. The monthly relative humidity data for the station and for the basin are shown in **Table 2-35**.

Table 2-35: Relative Humidity Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rel. Humidity, %	85	84	81	80	83	86	88	88	88	88	86	85

Source: PAGASA (1980-2010)

2.2.1.2.7 Wind

The southerly winds affect the project area between March to January. During the month of February, the prevailing winds are from the east. Each year, the area experiences several typhoons with destructive winds and torrential rains. The monthly normal and extreme wind speed and direction reckoned at the synoptic station in Malaybalay City are shown in **Table 2-36.**

Table 2-36: Wind Data

Wind	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Normal[1]						
Speed, mps	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Direction	S	E	S	S	S	S	S	S	S	S	S	S
Wind	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
						Extreme2						
Speed, mps	22	19	14	21	18	18	15	22	18	20	19	14
Direction	NE	NE	NE	NW	WNW	N	S	SW	NW	N	SW	NE

[1]Period of Record: 1981-2010
[2]Period of Record: 1950-2017
Source : PAGASA

2.2.1.2.8 SUNSHINE DURATION

The sunshine of a place is the duration from sun rise to sunset. Sunshine duration is the length of time that the ground surface is irradiated by direct solar radiation (i.e., sunlight reaching the earth's surface directly from the sun). The sunshine duration is measured using Campbell-Stokes recorder

which used a spherical glass lens to focus the sun rays on a specially designed tape. The amount of bright sunshine is affected by cloudiness, humidity, dustiness, latitudinal and altitudinal location, physical relief, annual march of the sun, and length of day and night. The seasonal changes in sunshine are basically connected to the variation in cloudiness. The region gets its maximum cloudiness in the cold months of December to January, consequently the least number of sunshine hours. It is observed that sunshine duration of the area is from 34% to 53% throughout the year. The statistical parameters of the actual sunshine duration of the area are summarized as shown below.

Month	Mean	Std Dev	Maximum	Minimum	Median	Cv
	hour/day					
Jan	4.2	1.0	6.7	3.1	4.1	0.23
Feb	5.6	1.1	7.6	3.8	5.6	0.20
Mar	6.1	0.9	7.6	4.6	6.0	0.14
Apr	6.5	0.7	7.7	5.6	6.4	0.11
May	6.0	1.0	7.0	4.2	6.4	0.17
Jun	4.9	1.1	7.1	3.3	5.0	0.23
Jul	4.3	1.0	5.9	2.7	4.1	0.23
Aug	4.7	1.1	6.5	2.7	4.6	0.24
Sep	4.9	1.1	7.3	3.3	4.9	0.23
Oct	5.0	0.9	6.3	3.7	5.0	0.18
Nov	5.3	0.9	6.6	3.4	5.4	0.18
Dec	5.0	0.9	6.3	3.6	5.2	0.18

Sunshine hours vary little throughout the year, ranging between 4.2 and 6.5 hours per day. There are more sunlight hours in the northeast monsoon season and less in the southwest monsoon season, with this being directly related to cloudiness. January has the lowest mean sunshine with 4.2 hours/day while April has the mean highest sunshine with 6.5 hours/day. The annual sunshine in the area increases from July to December then decreases in April until July.

The mean daily sunshine hours during the northeast monsoon season is about 5.4 hours with the month of April peaking up at 6.5 hours. During the southwest monsoon season the mean daily sunshine reduces to 5.0 hours with the month of July registering a low of 4.3 hours. The annual mean sunshine hour is about 5.2 hours. **Figure 2-32** shows the monthly sunshine hours.

The monthly dependable sunshine hours for the year in the area are also computed and the results are summarized as shown below.

Probability of Exceedance	50%	80%	90%	95%	98%
Sunshine Duration, hours	5.2	4.0	3.6	3.3	3.1

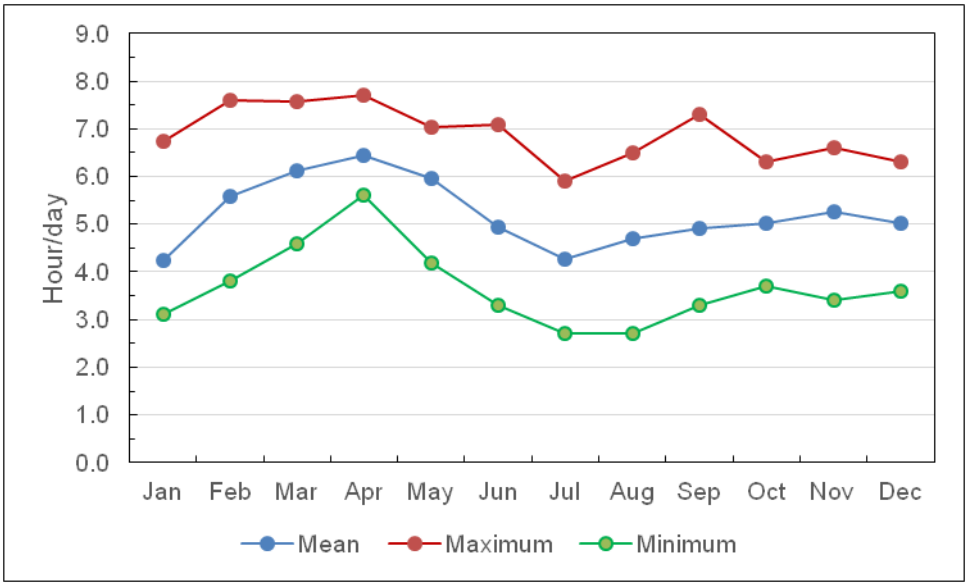


Figure 2-32: Actual Daily Sunshine Hours

2.2.1.2.9 Evaporation

Based on meteorological data for Malaybalay in the period 1981-2010, the mean daily evaporation rate is computed using Penman evaporation formula. The computed monthly evaporation data is shown in **Table 2-37.**

Table 2-37: Mean Daily Evaporation

Evaporation	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean, mm/day	3.73	4.35	4.83	5.09	4.80	4.29	3.98	4.23	4.34	4.23	4.09	3.89
Mean, mm/month	115.66	121.71	149.78	152.79	148.81	128.78	123.41	131.05	130.24	131.21	122.83	120.59

2.2.1.2.10 Evapotranspiration

Evapotranspiration is a process of mass transfer due to heat energy. It is the combined effect of evaporation as well as the transpiration. Evaporation can be defined as the process in which liquid water is converted to water vapor from the evaporating surface such as lakes, rivers, pavements, soil and vegetation; whereas, transpiration is a process of vaporization of liquid water from plant tissue and the vapor removal from the atmosphere.

The evapotranspiration rate from a reference surface, not short of water, is called the reference crop evapotranspiration or reference evapotranspiration and is denoted as ETo. The reference surface is a hypothetical grass reference crop that closely resembles an extensive surface of green, well-watered grass of uniform height, actively growing and completely shading the ground. Estimating the ETo requires several parameters, such as weather parameters (i.e., radiation, air temperature, wind speed, humidity); crop characteristics (type, variety, development stage); management and environmental aspects; etc.

The potential evapotranspiration was estimated using the FAO Penman-Monteith method. The method is expressed by the following equation.

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} U_2 (e_a - e_d)}{\Delta + \gamma(1 + 0.34U_{2)}}$$

where ETo = reference crop evapotranspiration, mm/day

Rn = net radiation at crop surface, MJ/m^2-day

G = soil heat flux, MJ/m^2-day

T = average temperature, °C

U_2 = wind speed measured at 2m height, m/s

(e_a-e_d) = vapour pressure deficit, kPa

Δ = slope vapor pressure curve, kPa/°C

γ = psychrometric constant, kPa/°C

900 = conversion factor

The above formula requires the latitude of the area of interest, elevation, temperature and wind velocity. The calculated monthly ET_0 is presented in **Table 2-38.**

Table 2-38: Potential Evapotranspiration

Evapotranspiration	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean, mm/day	3.26	3.83	4.24	4.46	4.24	3.80	3.53	3.76	3.86	3.75	3.60	3.40
Mean, mm/month	101.05	107.11	131.46	133.76	131.29	114.09	109.56	116.47	115.70	116.37	108.14	105.54

2.2.1.2.11 Water Balance

The planning, development and operation of water resources projects is very much dependent upon the availability of water in required quantity. The estimation of water balance is necessary for checking the reliability and general pattern of availability of water from month to month. In the present study, the normal water balance of Pulangi River at the dam site has been computed. The monthly water balance computations were performed using the procedure of Thornthwaite which uses an accounting method to analyze the allocation of water among various components of the hydrologic system. The water balance model was set-up in Microsoft Excel and computations were performed on a monthly basis. The potential evapotranspiration was estimated using the Penman-Montieth formula. Rainfall data and potential evapotranspiration were considered as input parameters. Field capacity for the soil was assumed as 100 mm for the damsite. Values of various parameters of average water balance were computed. **Table 2-39** shows the climatic water balance of Pulangi River at the dam site.

Table 2-39: Water Balance Computation for Pulangi Dam Site

	All values are given in mm												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (P)	152.98	108.34	103.15	111.19	241.97	317.58	333.93	316.06	311.10	306.85	187.99	150.54	2641.66
Pot. Evapt. (PE)	101.05	107.11	131.46	133.76	131.29	114.09	109.56	116.47	115.70	116.37	108.14	105.54	1390.53
P-PE (d)	51.94	1.23	-28.31	-22.56	110.68	203.49	224.37	199.59	195.39	190.48	79.85	45.00	1251.13
Soil Storage (St)	51.94	53.17	24.86	2.30	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
Change Storage (dSt)	51.94	1.23	-28.31	-22.56	97.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
AET	101.05	107.11	131.46	133.76	131.29	114.09	109.56	116.47	115.70	116.37	108.14	105.54	1390.53
Water Deficit, (WD) (P-AET)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water Surplus (WS)	0.00	0.00	0.00	0.00	12.98	203.49	224.37	199.59	195.39	190.48	79.85	45.00	1151.13
Soil Recharge/Withdrawal	-48.06	1.23	-28.31	-22.56	97.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Runoff	100.00	0.00	0.00	0.00	12.98	203.49	224.37	199.59	195.39	190.48	79.85	45.00	1251.13

Table 2-39 indicates that there is surplus of water during the months of May to October and no deficit of water during the remaining months of the year. Since the water surplus is in excess of precipitation over the water needs of the atmosphere and the soil, it must find its way through river and streams. From the above, the runoff in the catchment is about 47% of the precipitation.

2.2.1.3 Meteorological Hazard

2.2.1.3.1 General

The hydrological situation in a river system is related to many factors such as climate, hydrological runoff characteristics of the catchment like topography, soil and vegetation features, land use and size and shape of the catchment, reservoir regulation strategies and spillway capacity. Consequently a change in one or more of these factors will affect the hydrological load on the dam.

The location of the dam in Barangay Tangkulan in the Municipality of Damulog is exposed to meteorological and hydrologic phenomena which pose hazards to the facility. The meteorological and hydrological hazards presented herein are those caused by external events which are unconnected with the operation of a facility. The meteorological hazards include strong wind, heavy precipitation and thunderstorms and lightning would affect the site. These natural phenomena which when extremely occurs may endanger the health and lives of people or cause damage to properties.

2.2.1.3.2 Number of Rainy Days

The number of rainy days for the project area reckoned at Malaybalay City station is about 222 days in a year (1981-2010). The monthly distribution of rainy days is shown below. The rainiest month is either July or September while the least rainy month is April. The area receive rains 61% of the time in a year.

Number of Days w/	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rain	16	13	13	12	18	23	24	22	24	23	18	16	222

Source: PAGASA (1981-2010)

2.2.1.3.3 Heavy and Intensive Precipitation

Tropical cyclones during the southwest monsoon seasons and/or heavy thunderstorms cause localized and regional flooding which endangers lives of people and animals as well as, damage of properties. Per record of rainfall station at Malaybalay City, the maximum one day and monthly rainfall is shown below.

Duration	Maximum Rainfall, mm											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Day[1]	140.6	109.2	170.6	184.2	126.3	130.4	135.4	113.6	128.6	195.9	144.8	112.4
Month[2]	510.7	320.8	407.2	628.3	518.7	579.0	617.2	651.0	543.6	605.8	397.1	455.5

Source: [1]PAGASA (1981-2010) [2]PAGASA (1952-2017)

2.2.1.3.4 Strong Wind and Gustiness

The strong wind and gust is generally brought by tropical cyclones during the southwest monsoon season. The impact includes damage of properties, problems in transportation, damage of plants and individual trees, electric and communication tower, indirect impact on the safety of people and animals.

Annual maximum winds at Malaybalay City synoptic station of PAGASA are available for the year 1981-2017. The maximum wind recorded within this period is about 36 m/s or 129.6 km/hr. The statistical parameters of the monthly maximum winds are shown in **Table 2-40.**

In order to describe the behavior of extreme wind at the particular area, it is necessary to identify the distribution which best fits the observed data. The performance of a particular distribution however, depends on the method of the estimation of the parameters. The method of maximum likelihood is used in this study.

Table 2-40: Statistical Parameters of Monthly Maximum Wind

Month	Mean	Stdev	Max	Min	Median	Cv
	Wind Speed, m/s					
Jan	10.2	2.1	14.0	8.0	10.0	0.21
Feb	9.7	1.8	14.0	8.0	9.0	0.19
Mar	11.6	6.4	36.0	8.0	10.0	0.55
Apr	9.4	1.3	12.0	8.0	9.0	0.14
May	10.7	2.8	15.0	8.0	10.0	0.26
Jun	10.7	2.7	18.0	8.0	10.0	0.25
Jul	10.5	2.2	15.0	8.0	10.0	0.21
Aug	11.0	2.9	22.0	8.0	10.0	0.27
Sep	10.9	4.1	23.0	8.0	9.5	0.37
Oct	10.7	3.3	20.0	8.0	10.0	0.31
Nov	11.7	3.2	17.0	8.0	11.0	0.28
Dec	10.6	2.2	15.0	8.0	10.0	0.21

Some common probability distributions such as Normal, Lognormal, Gumbel, Generalized Extreme Value, Pearson and Log Pearson were considered. The adequacy of the probability distribution models in fitting the observed annual maximum wind were evaluated by goodness of fit test criteria. In particular, the relative root mean square error (RRMSE) is adopted at it provides a better picture of the overall fit of a distribution as it calculates each error in proportion to the size of observation thereby reducing the influence of outliers which are common features of hydrological data. The Log Normal Type 3 (LN3) distribution provided the least value of RRMSE and high value of Nash-Sutcliffe efficiency. The best fit distribution model (LN3) was therefore used to obtain estimates of quantile for a range of return periods. The calculated quantile estimates for the selected return periods are presented in **Table 2-41.**

Table 2-41: Quantile Estimation Using LN3 for Different Return Periods

Return Period, yrs	10	20	25	50	100	200	500	1000	10000
Wind Speed, m/s	20.04	22.72	23.59	26.34	29.18	32.11	36.17	39.38	51.03
Wind Speed, km/hr	72.15	81.80	84.93	94.83	105.03	115.60	130.19	141.75	183.72

2.2.1.3.5 Thunderstorms

Thunderstorms are produced by cumulonimbus clouds accompanied by lightning and thunder. They are usually of short duration but are able to produce strong wind gusts and heavy rainfall.

Lightning is a visible electrical discharge and exhibit extremely high voltages, currents and current rise rates. Damage is usually categorized as either direct or induced (indirect). The extreme electric field created under certain circumstances produces point discharges and can cause breakdown (a conductive path) in all but the most robust of insulators. The mean monthly thunderstorms and lightning for the area reckoned at Malaybalay City Station (1981-2010) is as follows.

Number of Days w/	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thunderstorm	1	2	3	6	14	13	14	13	15	15	7	3	106
Lightning	1	1	2	6	11	9	9	9	10	11	7	4	80

Source: PAGASA (1981-2010)

The months with the highest mean number of thunderstorms days are September and October while the month of October has the highest recorded mean number of lightning. On the average there are 106 days in a year with thunderstorm and 80 days with lightning spread unevenly throughout the year.

2.2.1.4 Climate Change

2.2.1.4.1 General

Climate change will affect key hydrological parameters of relevance to hydropower generation in the Pulangi River Basin. Changes in temperature and precipitation patterns (including the volume, timing, and intensity of rainfall, and relative proportion of rainfalll) affect the timing, magnitude, and duration of river flows, the frequency of droughts and floods, the rate of evaporative water loss, and the influx of groundwater for baseflows. Hydrological variability over time in a catchment is influenced by variations in precipitation over daily, seasonal, annual, and decadal time scales. Flood frequency is affected by changes in the year-to-year variability in precipitation and by changes in short-term rainfall properties (such as storm rainfall intensity). The frequency of low or drought flows is affected primarily by changes in the seasonal distribution of precipitation, year-to-year variability, and the occurrence of prolonged droughts (Snidvongs et al. 2003).

Global warming is the increase in the earth's average temperature due to the buildup of carbon dioxide and other greenhouse gases in the atmosphere from human activities. There is concrete evidence that the earth is indeed warming up, and such warming is attributed to the dramatic rise in human-induced greenhouse gas emissions since the middle of 20th-century. The Intergovernmental Panel on Climate Change (IPCC), the international body tasked with studying the greenhouse effect, concluded that the warming has become “evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.”

Global warming is causing climate change. The Philippines incessantly confronts the predicament of being prone to both natural and man-made disasters. Climate change will influence Philippine weather in terms of changes in temperature, rainfall, and tropical cyclone activity and sea level rise.

2.2.1.4.2 Temperature

PAGASA has conducted a study on the temperature trends using available observed data from 1951 to 2009 with the average for the period of 1971 – 2000 as the reference value. The key finding indicates that all areas of the Philippines will get warmer, more so in the relatively warmer summer months. Annual mean temperatures (averages of maximum and minimum temperatures) in all areas of the country are expected to rise by 0.9°C to 1.1°C in 2020 and by 2.2°C in 2050. Likewise, all seasonal mean temperatures will also have increases. For the province of Bukidnon, the following table provides likely scenario for the year 2020 and 2050 as projected by PAGASA.

Province	Observed Baseline (1971-2000), °C				Change in 2020, °C				Change in 2050, °C			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Bukidnon	25.1	26.5	25.8	25.7	1.0	1.2	1.2	1.0	1.9	2.3	2.4	2.1

DJF - (Dec-Jan-Feb) **MAM - (Mar-Apr-May)** **JJA - (Jun-Jul-Aug)** **SON - (Sep-Oct-Nov)**

However, projections for extreme events in 2020 and 2050 show that hot temperatures will continue to become more frequent. Under the medium-range emission scenario of PAGASA, the frequency of extreme temperature events in the province of Bukidnon is shown below.

Province	No. of Days with Tmax > 35 °C		
	1971-2000	2020	2050
Bukidnon	26	477	1441

The increase of temperature in the area will intensify evapotranspiration which will lead to less runoff and in combination with less precipitation, implying a possible reduction in renewable water supplies for irrigation, domestic and industrial use, recreation and hydropower. The frequency and severity of droughts could increase also in the area as a result of a decrease in total rainfall, more frequent dry spells, and higher water evaporated from the surface and transpired from plants.

2.2.1.4.3 Rainfall

Precipitation patterns or trends directly impacts runoff levels and stream flows which then determine the amount of water available for hydroelectric generation. Changes in precipitation cycles due to climate change can alter river flow patterns, resulting in longer periods of drought that decrease rivers' minimum water levels and hence hydroelectric generation capacity. Another potential consequence of altered river flow patterns is the increased incidence of elevated flow rates and flooding that exceed the safety margins of existing hydroelectric plants. On the other hand, increased flow rates, if timed correctly, might result in increased hydropower generation.

In terms of seasonal rainfall change, generally there is a substantial spatial difference in the projected changes in rainfall in 2020 and 2050 in most parts of the Philippines, with reduction in rainfall in most provinces during the summer months making the usually dry season drier, while rainfall increases are likely in most areas of Luzon and Visayas during the southwest monsoon seasons, making these seasons still wetter, and thus with likelihood of both droughts and floods. The northeast monsoon season rainfall is projected to increase, particularly for areas characterized by Type II climate with potential for flooding enhanced. During the southwest monsoon season, larger increases in rainfall is expected in provinces in Luzon (0.9% to 63%) and Visayas (2% to 22%) but generally decreasing trends in most of the provinces in Mindanao in 2050. For the province of Bukidnon, the following table provides likely scenario for the year 2020 and 2050 as projected by PAGASA.

Province	Observed Baseline (1971-2000), mm				Change in 2020, %				Change in 2050, %			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Bukidnon	329.7	335.6	653.8	559.5	2.9	-10.3	-4.4	-0.3	-5.3	-13.0	-9.7	-5.8
DJF - (Dec-Jan-Feb)			MAM - (Mar-Apr-May)				JJA - (Jun-Jul-Aug)				SON - (Sep-Oct-Nov)	

The number of dry days (days with less than 2.5mm of rain) will increase in all parts of the country and heavy daily rainfall (exceeding 200mm) events will also continue to increase in number in Luzon and Visayas. For the province of Bukidnon, the following table provides likely scenario for the year 2020 and 2050 as projected by PAGASA.

Province	No. of Dry Days			No. of Days with Rainfall >150 mm		
	1971-2000	2020	2050	1971-2000	2020	2050
Bukidnon	6537	3977	4461	4	9	9

The number of intense precipitation days will likely increase as a result of reduction in the number of dry days. The frequency of floods in low lying areas in the basin will likely increase and more annual runoff caused by the increased precipitation in the basin.

2.2.1.4.4 Tropical Cyclones

Analysis of trends of tropical cyclone occurrence or passage within the so-called Philippine Area of Responsibility (PAR) show that an average of 20 tropical cyclones form and/or cross the PAR per year. The trend shows a high variability over the decades but there is no indication of increase in the frequency. However, there is a very slight increase in the number of tropical cyclones with maximum sustained winds of greater than 150kph and above (typhoon category).

Moreover, the analysis on tropical cyclone passage over the three main islands (Luzon, Visayas and Mindanao), the 30-year running means show that there has been a slight increase in the Visayas during the 1971 to 2000 as compared with the 1951 to 1980 and 1960-1990 periods.

Due to the shifts in the climate patterns, there are projections for fewer typhoons in January to March while frequency will increase in July to November. Typhoons will affect Visayas and Mindanao mainly in December when sea-surface temperatures (SSTs) remain warm enough. In theory, warmer SSTs mean more frequent and stronger storms. At present, there are no clear trends as to how global warming will change the vertical wind structure (or wind shear) which, with the distribution of moisture, influences typhoon development (Manila Observatory, 2007).

2.2.1.4.5 Impacts on Watershed and Reservoir

The expected rainfall in the project area is projected to decrease during the dry months which will affect the amount of water in the watersheds and dams thereby rendering insufficient rainfall amount which will affect the energy sufficiency program of the area. Critical water shortages can be expected leading to possible reduction of water available for energy generation.

Likewise rainfall in the area could be intense during wet periods and would pose danger to human settlements and infrastructure, in terms of landslides and mudslides most especially in geologically weak areas. Additionally, these flooding events could impact severely on public infrastructure in low-lying areas.

2.2.1.5 Rainfall Analysis

2.2.1.5.1 General

Rainfall is one of the primary drivers of the hydrological cycle, with its volume and intensity directly affecting the volume of water available within a catchment. The success or failure of crops particularly under rainfed condition is closely linked with amount and distribution of rainfall. When rainfall during a period of year is low or ill distributed, it becomes difficult for the crops raised to meet their evapotranspiration requirement and that leads to crop failure. On the other hand, if the rainfall is too high, it causes higher rate of runoff, resulting in landslides and floods. Hence knowledge on rainfall distribution over a catchment/watershed is a pre-requisite for proper planning and design of various soil and water conservation structures.

Rain gauge gives relatively accurate point measurement of rainfall but observations are not available over most remote land areas and in the river basin in particular. The sources of rainfall observations for the study area (1970-2017) is the nearest rainfall station located in Malaybalay City. The analysis of rainfall data at the station deals with interpreting past record of rainfall events in terms of future probabilities of occurrence.

2.2.1.5.2 Basin Rainfall

The average rainfall in the basin is heavily influenced by monsoon and terrain. Rainfall distribution is uneven by time and space. The watershed rainfall at the dam site is reckoned from the nearest synoptic station. The Malaybalay synoptic station would likely influence the rainfall pattern and behavior in the Pulangui River basin.

2.2.1.5.2.1 Annual and Monsoonal Rainfall

The mean annual rainfall in the project area reckoned at Malaybalay City station varies from a low of 1,864.8 mm to a high of 3,746.3 mm. The mean annual rainfall depth in the project area is about 2,702.1 mm. The total rainfall during the southwest monsoon (May-October) is about 68 percent of the yearly total. The ratio of the highest and lowest annual precipitation to the long-term mean is 1.39 and 0.69, respectively. The annual rainfall statistics including monsoonal rainfall as computed are given as follows;

	Unit	Annual	SW Monsoon	NE Monsoon
Mean	mm	2,702.1	1,842.8	831.0
Stdev	mm	459.1	299.5	310.4
Median	mm	2,752.8	1,840.9	785.8
Maximum	mm	3,746.3	2,522.5	1,839.7
Minimum	mm	1,864.8	1,243.5	287.4
Cv	-	0.17	0.16	0.37

The distribution of annual rainfall showing an annual increase in trend is shown in **Figure 2-33**.

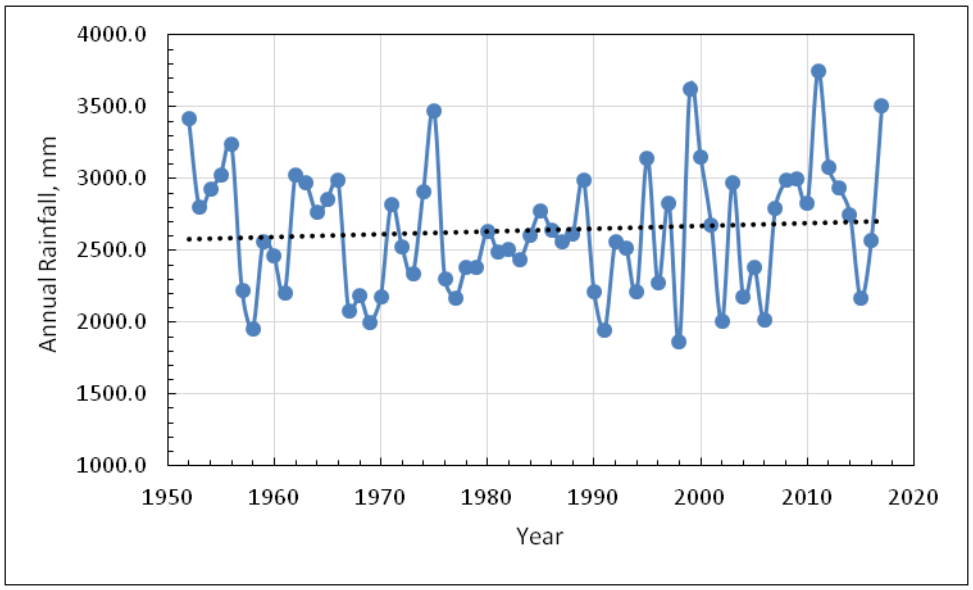


Figure 2-33: Annual Rainfall Distribution (Malaybalay City Station)

The dependable rainfall which is defined as the amount of rainfall that can be expected or might be exceeded in a given period for a specific probability. It refers to the minimum amount of rain one can rely on during the reference period. The probability of exceedance refers to the probability of the

occurrence of rainfall depth greater than some given value. The dependable rainfall for the area is calculated and summarized as shown below.

Prob. Of	Dependable Rainfall, mm		
Exceedance	Annual	SW Monsoon	NE Monsoon
50%	2,752.8	1,840.9	785.8
60%	2,576.5	1,777.7	707.9
70%	2,467.9	1,663.0	617.4
80%	2,215.6	1,529.7	553.1
90%	2,017.3	1,446.4	487.5
95%	1,969.4	1,364.9	367.2

2.2.1.5.2.2 Seasonal Rainfall

To identify the seasonal rainfall distribution, the whole year was divided into three periods. The rainfall change by seasons (e.g., DJF or northeast monsoon season, MAM or summer season, JJA or southwest monsoon season, and SON or transition from southwest to northeast monsoon season). The seasonal rainfall statistics for the project area for the years 1952-2017 are summarized below.

	DJF	MAM	JJA	SON
Mean	419.9	448.5	982.8	809.0
Stdev	188.6	208.1	192.3	166.3
Median	376.2	417.5	982.7	812.2
Maximum	951.4	1,221.1	1,492.3	1,205.1
Minimum	109.7	69.4	670.8	459.9
Cv	0.45	0.46	0.20	0.21

Units are all in mm except Cv where it is dimensionless

The seasonal rainfall variation in the project area is shown in **Table 2-42**. It indicates that 63% of rainfall occurs in the southwest monsoon and a little less than 1% occurs in the northeast monsoon season.

Table 2-42: Seasonal Rainfall Pattern in Malaybalay, Bukidnon

Season	Period	% of Annual Precipitation
NE Monsoon	December-February	15.78
Dry Season	March-May	16.86
SW Monsoon	June-August	36.95
Post Monsoon	September-November	30.41

2.2.1.5.2.3 Monthly Rainfall

Rainfall occurs primarily from May to October and provides water for the growth of crops. Most of the rainfall is consumed by seasonal evaporation, which leads to little surface runoff during December to April.

The project area has very pronounced seasons. It has pronounced dry period from November to April and wet during the rest of the year. August is the wettest month with a mean monthly rainfall of 571.1

mm while February is the driest month at 2.3 mm. The monthly rainfall data based on Malaybalay station are shown in **Figure 2-34**.

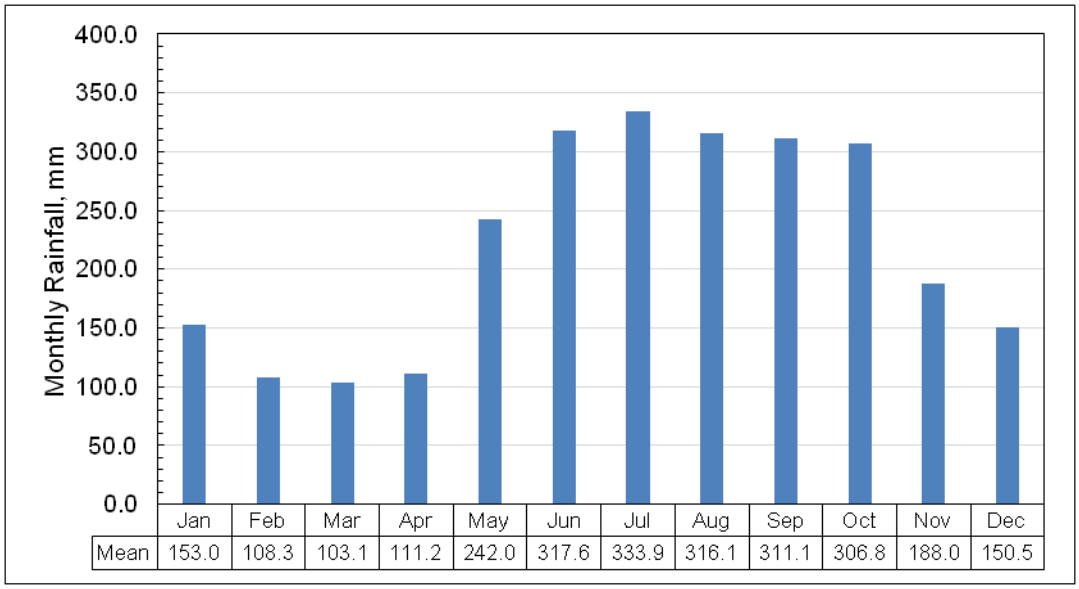


Figure 2-34: Mean Monthly Rainfall (Malaybalay City Station)

The following table gives the summary statistics of the monthly precipitation from 1952-2017.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean	153.0	108.3	103.1	111.2	242.0	317.6	333.9	316.1	311.1	306.8	188.0	150.5
Stdev	111.0	72.6	79.7	106.5	95.6	93.4	104.5	102.1	103.6	111.7	86.6	93.9
Median	123.7	96.6	82.9	73.4	240.4	303.6	324.8	311.2	334.3	300.7	169.8	134.1
Maximum	510.7	320.8	407.2	628.3	518.7	579.0	617.2	651.0	543.6	605.8	397.1	455.5
Minimum	2.5	1.0	4.9	4.0	60.5	138.1	113.9	96.1	58.2	75.9	41.6	14.3
Cv	0.73	0.67	0.77	0.96	0.40	0.29	0.31	0.32	0.33	0.36	0.46	0.62

All units are in mm except for Cv where the unit is dimensionless

The variability of monthly rainfall is described by the coefficient of variation, Cv. The coefficient of variation during the northeast monsoon varies from a low of 0.46 to a high of 0.96. During the southwest monsoon, the coefficient of variation varies from 0.29 to 0.40.

2.2.1.5.3 Precipitation Concentration Index

The concentration of rainfall in a year is also an important aspect of climate. An unbalanced distribution of rainfall evokes periods of rainfall excess and periods of drought. Rainfall heterogeneity over a period of time can be investigated using the Precipitation Concentration Index (PCI). The PCI of annual and seasonal rainfall is used to quantify the relative distribution of rainfall patterns. The rainfall change by seasons (e.g., DJF or northeast monsoon season, MAM or summer season, JJA or southwest monsoon season, and SON or transition from southwest to northeast monsoon season) are calculated by the following equations which were introduced by Oliver (1980) and further modified by De Luis et al (2000).

$$PCI_{annual} = \frac{\sum_{i=1}^{12} p_i^2}{\left(\sum_{i=1}^{12} p_i\right)^2} 100 \qquad PCI_{seasonal} = \frac{\sum_{i=1}^{3} p_i^2}{\left(\sum_{i=1}^{3} p_i\right)^2} 25 \qquad PCI_{supraseasonal} = \frac{\sum_{i=1}^{6} p_i^2}{\left(\sum_{i=1}^{6} p_i\right)^2} 50$$

where p_i is the monthly precipitation. According to this classification, Oliver (1980) suggested the following description of PCI values

Rainfall Regime	PCI Class Limits
Uniform Precipitation	<10
Moderate Precipitation	10 < PCI <=16
Irregular Distribution	16 < PCI <=20
Strong Irregularity	>20

The temporal variability of rainfall in Malaybalay City is calculated as follows.

Period of Time	PCI value	Rainfall Regime
Annual	11.15	Moderate Distribution
NE Monsoon	11.63	Moderate Distribution
SW Monsoon	9.12	Uniform Distribution
DJF	10.52	Moderate Distribution
MAM	11.69	Moderate Distribution
JJA	8.78	Uniform Distribution
SON	9.56	Uniform Distribution

The derived PCI values for Malaybalay City station show that rainfall is uniformly distributed during the southwest monsoon season and moderately distributed during the northeast monsoon season. Annual rainfall is moderately distributed.

2.2.1.5.4 Standard Precipitation Index

The occurrence of flood spells is difficult to monitor and detect. However, there are some indices that permit to monitor hydrological and climatological conditions in river basins. The SPI is one of those indices. Though the SPI was originally developed for drought detection and monitoring, it can also be applied to perceive wetter than normal conditions. A positive value of SPI indicates that precipitation is above average and a negative value, below average, consequently, values of SPI ranging from -1 to +1 express a normal rainfall amount. Values of SPI ranging from +1 to 1.5 and 1.5 to +2.0 are associated with moderately wet and very wet episodes, respectively, and SPI values exceeding +2 are representative of extremely wet episodes. Moderately dry, very dry and extremely dry spells are characterized by the same SPI ranges with a negative sign.

The Standardized Precipitation Index (SPI) is a widely used index to characterize meteorological drought/flood on a range of timescales. It quantifies observed precipitation as a standardized departure from a selected probability distribution function that models the raw precipitation data. The raw precipitation data are typically fitted to a gamma probability distribution, and then transformed to a normal distribution which by definition has zero mean and unit variance. The SPI values can be interpreted as the number of standard deviations by which the observed anomaly deviates from the long-term mean. The SPI can be created for differing periods of 1-to-36 months, using monthly input

data. Hence the SPI indicates the number of standard deviations that a particular rainfall event deviates from normal conditions. The classification of dry and wet events resulting from the SPI calculation is shown below.

SPI	Classification	SPI	Classification
0.00 to -0.99	Near Normal	0.00 to 0.99	Near Normal
-1.00 to -1.49	Moderately dry	1.00 to 1.49	Moderately wet
-1.50 to -1.99	Severely dry	1.50 to 1.99	Severely wet
<= -2.00	Extremely dry	<= 2.00	Extremely wet

The SPI can be computed for different time scales and can provide early warning of drought/flood, and help assess drought/flood severity. Anomalously wet and dry events may easily be determined. SPI requires long term data (i.e. 30 years or more). It can use to monitor drought/flood at different time scales but cannot use to predict.

2.2.1.5.4.1 Annual Rainfall

Using the mean annual rainfall of the nearest station which is situated at Malaybalay City the yearly SPI values for the project area are shown in **Figure 2-35.**

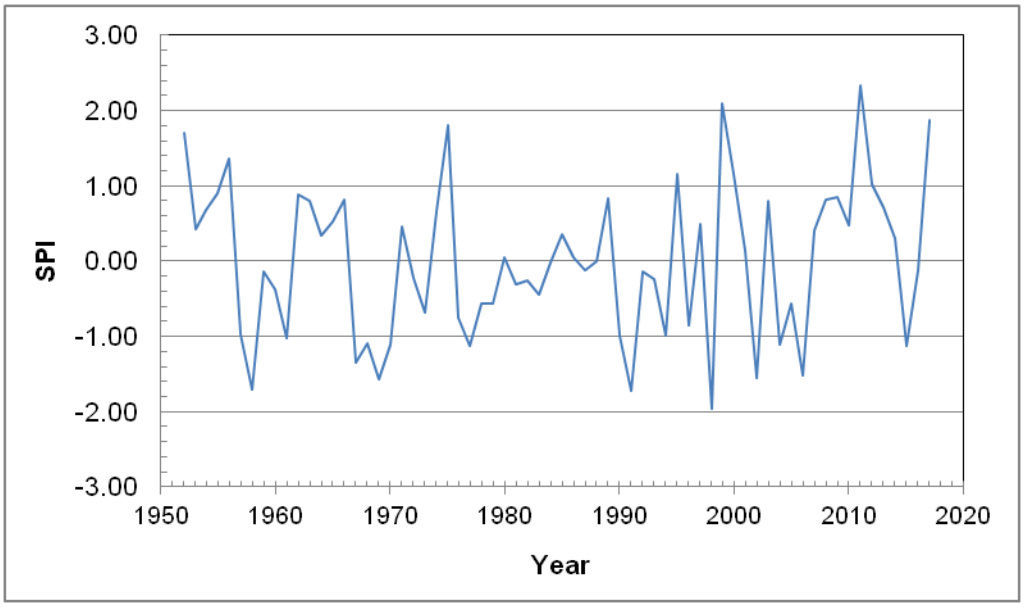


Figure 2-35: SPI Values of Annual Rainfall in Malaybalay City

The project area had experienced extreme dryness in the year 1998. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. Severely wet condition occurred in 2011. The probability of recurrence of drought/flood for the project area reckoned at Malaybalay City station is given as follows:

SPI	Category	Number of Times in 66 yrs (1952-2017)	Severity of Event
0 to -0.99	Near normal	21	1 in 3.1 yrs
-1.00 to -1.49	Moderately dry	7	1 in 9.4 yrs
-1.50 to -1.99	Severely dry	6	1 in 11.0 yrs
<-2.0	Extremely dry	0	-
0 to 0.99	Near normal	23	1 in 2.9 yrs
1.00 to 1.49	Moderately wet	4	1 in 16.5 yrs
1.50 to 1.99	Severely wet	3	1 in 22.0 yrs
< 2.0	Extremely wet	2	1 in 33.0 yrs

The drought season which is defined by moderately and severely dry category was restricted to occurrence of moderate and strong El Niño events, respectively while moderately wet and severely wet category are the thresholds for moderate and strong La Niña episodes.

2.2.1.5.4.2 Monthly and Seasonal Rainfall

The SPI values of the rainiest month of July and the high seasonal rainfall from June-July-August (JJA) were computed as shown in **Figure 2-36**.

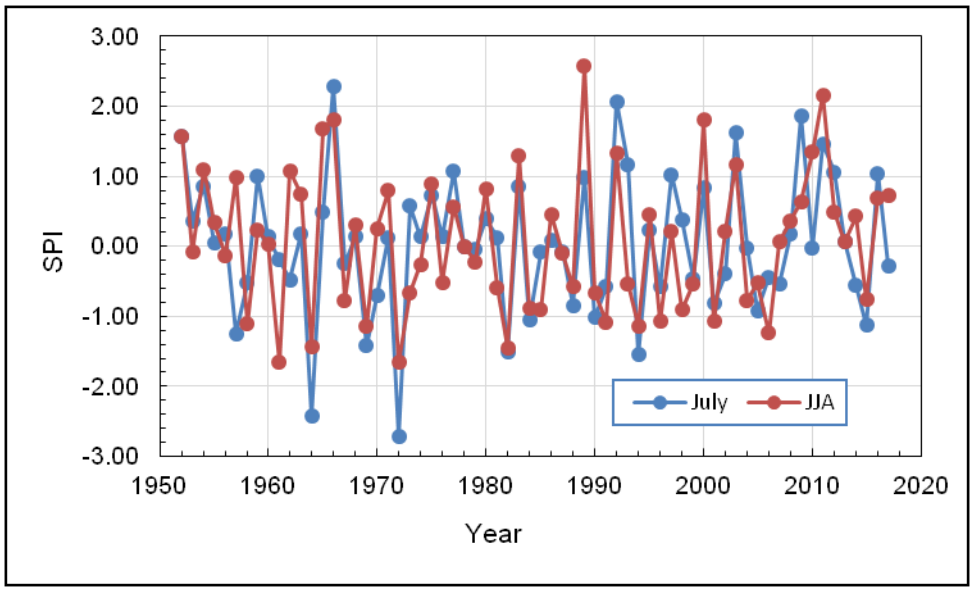


Figure 2-36: SPI Values of Mean Monthly and Seasonal Rainfall

The project area had experienced extreme seasonal dryness in July 1964 and 1972 and severely seasonal wet period in 1989. The probability of recurrence of flood/drought for the project area reckoned at Malaybalay City station is given as follows:

SPI	Category	July		June-July-August	
		Number of Times in 66 yrs (1952-2017)	Severity of Event	Number of Times in 66 yrs (1952-2017)	Severity of Event
0 to -0.99	Near normal	21	1 in 3.1 yrs	20	1 in 3.3 yrs
-1.00 to -1.49	Moderately dry	5	1 in 13.2 yrs	9	1 in 7.3 yrs
-1.50 to -1.99	Severely dry	2	1 in 33.0 yrs	2	1 in 33.0 yrs
<-2.0	Extremely dry	2	1 in 33.0 yrs	0	-
0 to 0.99	Near normal	24	1 in 2.8 yrs	23	1 in 2.9 yrs
1.00 to 1.49	Moderately wet	7	1 in 9.4 yrs	6	1 in 11.0 yrs
1.50 to 1.99	Severely wet	3	1 in 22.0 yrs	4	1 in 16.5 yrs
< 2.0	Extremely wet	2	1 in 33.0 yrs	2	1 in 33.0 yrs

2.2.1.5.5 Probable Maximum Precipitation (PMP)

Probable Maximum Precipitation (PMP) is the greatest depth of precipitation that is meteorologically possible for a given location, and its estimation is essential for assessing the safety of dams, and for planning flood disaster preparedness and flood mitigating measures.

Statistical estimate of PMP was made using the method developed by Hershfield (1961) and based on the general frequency equation developed by Chow (1951). Hershfield considered that for PMP estimation, there is a value of frequency factor which will not exceed, say K_m. He then modified Chow's equation as:

$$X_{PMP} = \mu_n + K_m \sigma_n$$

where X_{PMP} is PMP for the given set of data, μ_n and σ_n are the mean and standard deviation of annual maximum, respectively. The K_m factor is calculated using the following equation:

$$K_m = (X-\mu_{n-1}) / \sigma_{n-1}$$

where X is the highest observed annual maximum rainfall in the series, and μ_{n-1} and σ_{n-1} are the mean and standard deviation of the annual maximum, respectively, when the highest value is excluded in calculating the parameters.

In an analysis of many world-wide precipitation records, Hershfield (1961) found that K never exceeded the value of 15. However, the value of 15 may be too high for areas of generally heavy rainfall and too low for arid areas (World Meteorology Organization, 1973). As PMP deals with unusual rainfall values, the corresponding frequency factor must also be chosen from the extremely high values.

The calculated PMP parameters for Pulangi watershed are as follows:

Station	**Maximum one-day Rainfall, mm**	**Mean**	**Cv**	**X_{PMP}**
Davao	193.0	100.1	0.30	478.0
Tagum	226.2	114.0	0.35	613.6
Malaybalay	195.9	108.2	0.30	504.3

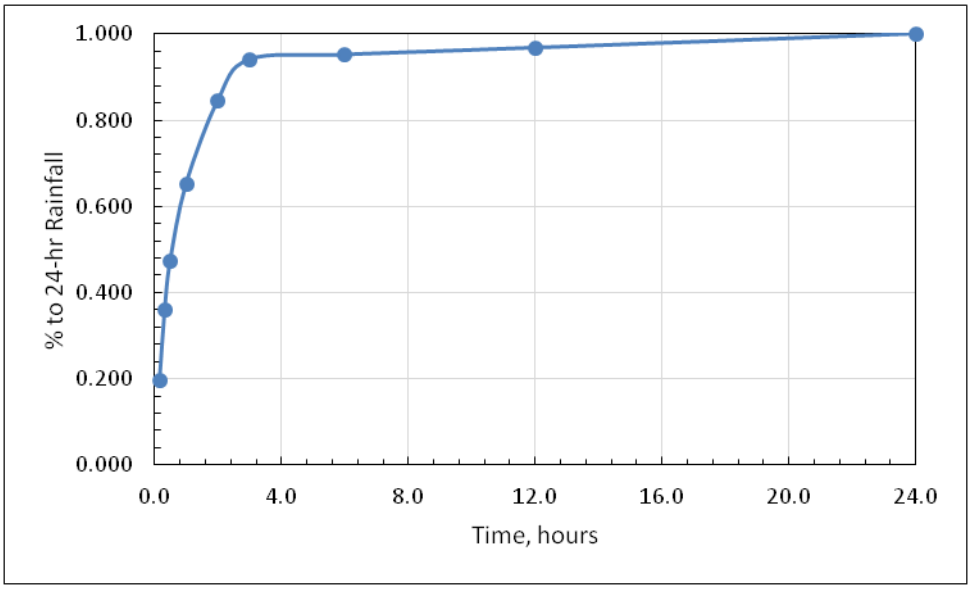
Station	Maximum one-day Rainfall, mm	Mean	Cv	X_{PMP}
Hinatuan	375.5	375.5	0.36	1153.1
Butuan	271.6	133.1	0.30	630.9
Cotabato	460.0	104.9	0.71	1024.5

The distribution of 24-h PMP has exhibited patterns with high and low PMP values in certain areas. Using the inverse distance weighting method , the Pulangi V basin is computed to have a PMP of about 512.7 mm.

The above results indicate that for project area, the statistical estimates of PMP are probably in the order of 2.6 times the highest recorded rainfall in the nearest synoptic station which is at Malaybalay.

2.2.1.5.5.1 PMP Temporal Distribution

A temporal distribution of X_{PMP} needs to be presented for its application in estimating the corresponding probable maximum flood. For this purpose, the temporal distribution of PMP for nearby station at Malaybalay was used**. Figure 2-37** shows the proposed temporal distribution of 24-h PMP at the project area.



Time, hours	0.167	0.333	0.500	1.000	2.000	3.000	6.000	12.000	24.000
PMP Rainfall, mm	100.1	184.5	241.7	333.9	433.1	482.2	487.9	496.0	512.7
% to 24-hr Rainfall	0.195	0.360	0.472	0.651	0.845	0.941	0.952	0.968	1.000

Figure 2-37: Temporal Distribution of PMP at the Project Area

2.2.2 Water Quality

2.2.2.1 Introduction

2.2.2.1.1 Project Background

The proposed dam for the project is located across Pulangi River while the proposed powerhouse is situated approximately 300 meters from the dam (**Figure 2-38**). The Pulangi River is the main location for sampling of the water quality of the project. The headwaters are located south of Kalatungan Mountain, Kitanglad Mountain in the west and Mount Amaloi in the east. According to the EIS conducted by Berkman Systems Inc. (BSI) in 2011 for the Pulangi V Hydroelectric Power Plant Project, the water quality of Pulangi River was within standards of DAO 1990-34.

In order to further assess the surface and groundwater quality of the project, sampling stations were established by LTI. A total of five (5) surface water and one (1) groundwater stations were sampled as illustrated in **Figure 2-39**. The parameters that were tested included total suspended solids, oil and grease, biochemical oxygen demand, dissolved oxygen, temperature, pH, total dissolved solids, salinity and conductivity. According to the Environmental Management Bureau under the Water Quality Management Section, the Pulangi River is classified as Class A which is a public water supply class that is intended as sources of water supply requiring conventional treatment to meet latest PNSDW. Due to security reasons, the other tributaries were unsampled during the sampling event.

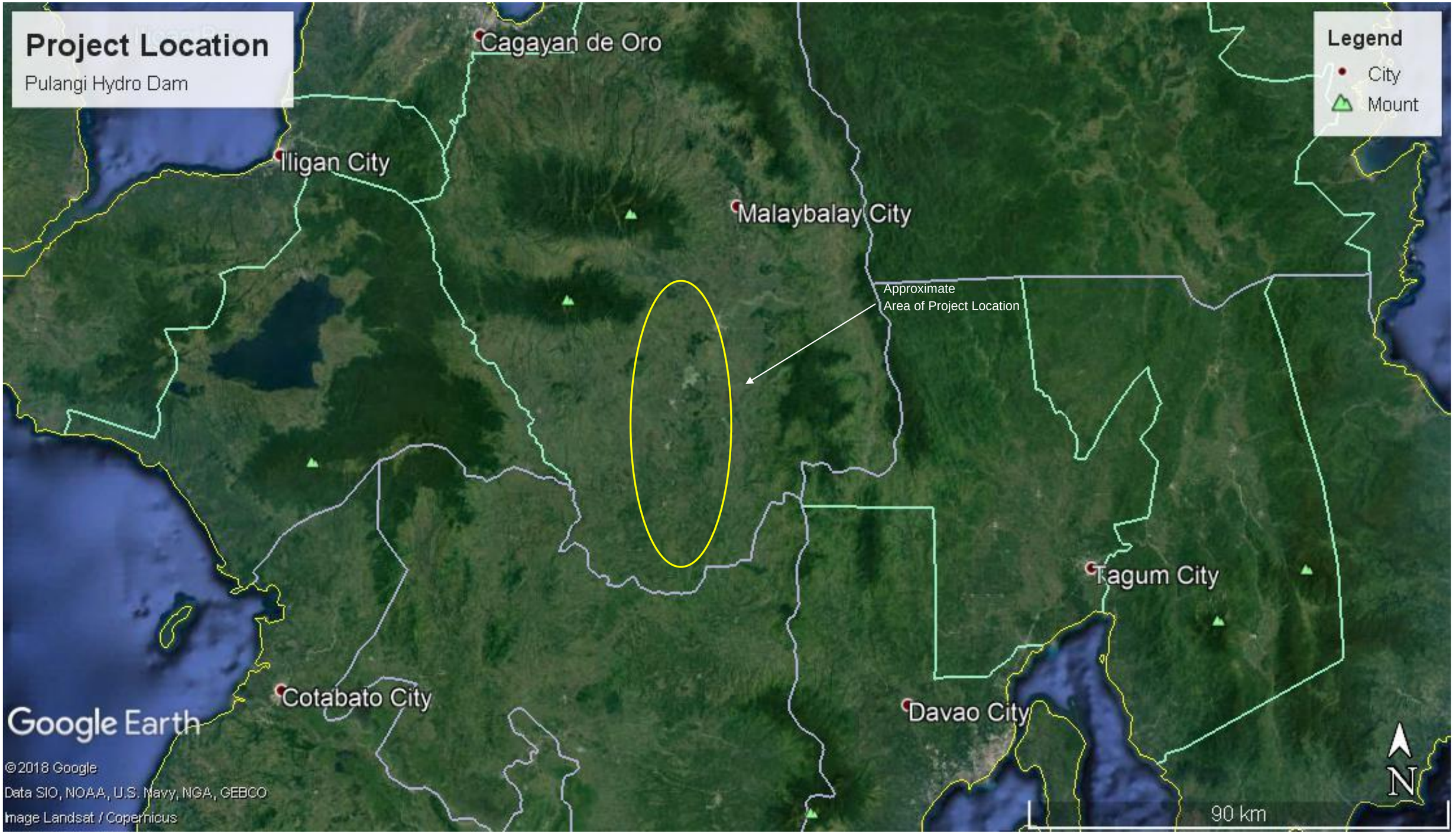
2.2.2.1.2 Objectives of the Study

The main objective of the study is to conduct water quality sampling during the construction and commissioning phase of the Pulangi Hydro Dam.
The specific objectives of the study are the following:

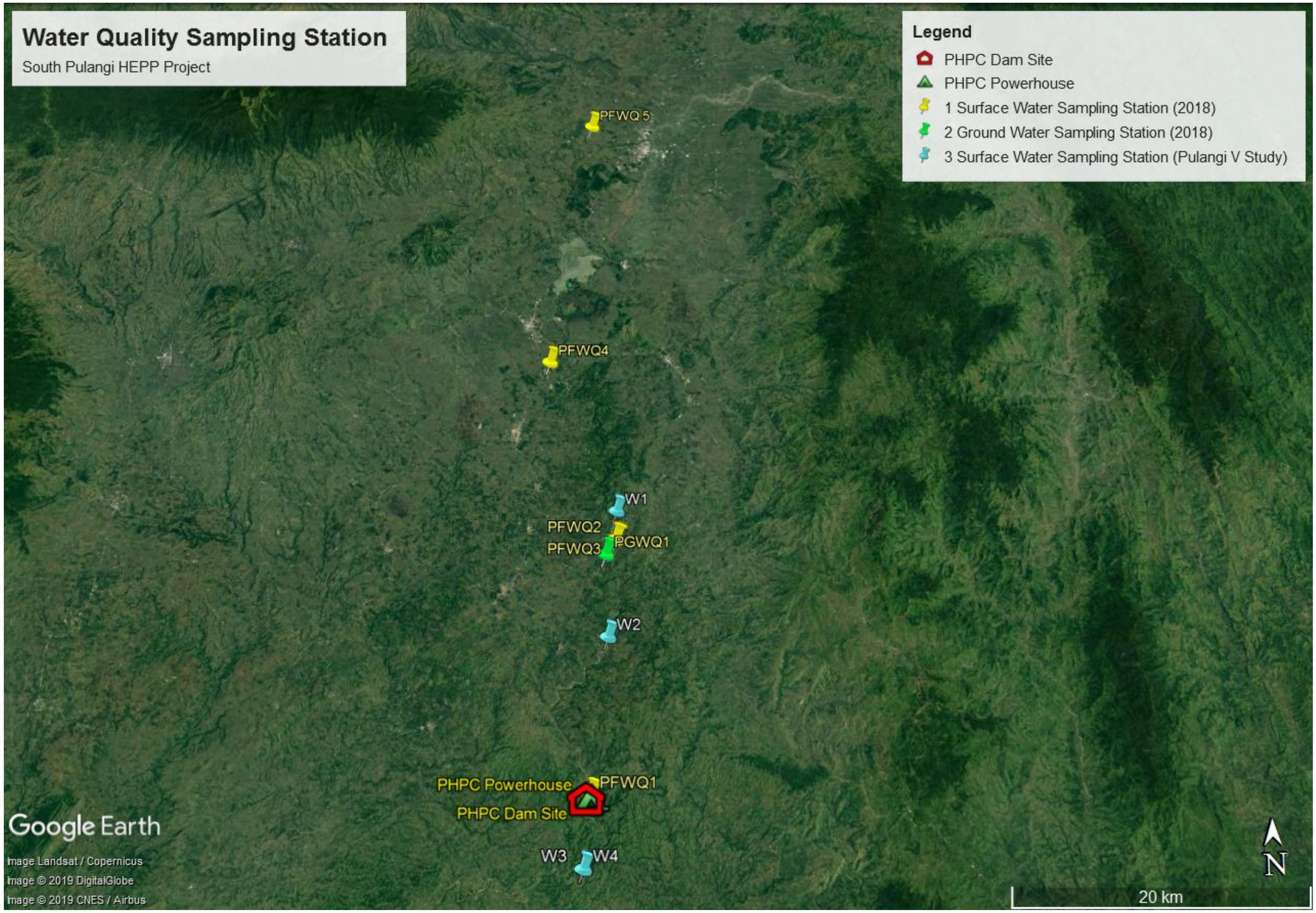
- To sample surface water and groundwater, with laboratory analysis for selected parameters to confirm/supplement characterizing analyses based on the gathered data and additional data
- To formulate and evaluate of updated strategies that could mitigate negative effects (e.g. development of containment mechanism for eroded soil)
- To compare the results of in-situ measurements and laboratory analysis with the guidelines set in DAO 08-2016 (for surface and groundwater) and PNSDW (for groundwater used for drinking purposes)

2.2.2.1.3 Direct and Indirect Impact Areas

As per section 10 of DENR Administrative Order 15 series of 2017, the direct areas of impact of the water quality includes Pulangi River and its tributaries, the Dam site and the power plant. The indirect areas include the land area within 50 m radius from the project site (**Figure 2-40**).



Lichel Technologies, Inc. Unit 1403 Prestige Tower Condominium F. Ortigas, Jr. Road, Ortigas Center, Pasig City	FIGURE TITLE : **Project Location**	FIGURE NO.: **2-38**



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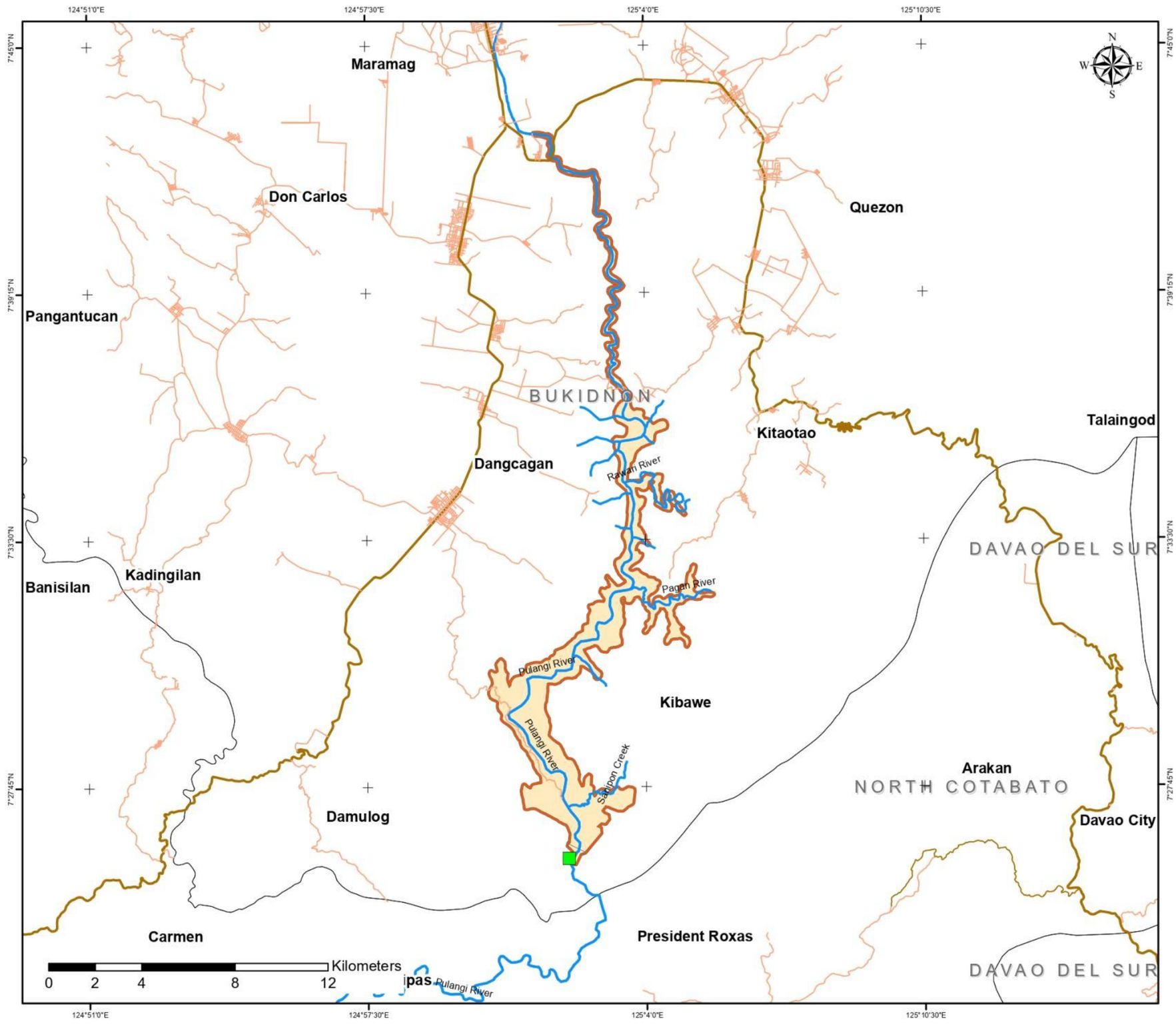
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

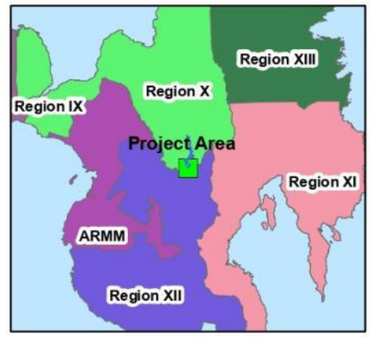
FIGURE TITLE :

Location of Water Quality Sampling Stations

FIGURE NO.:

2-39





1:150,000

Legend

- Dam
- River
- National Highway
- Direct Impact Area
- Indirect Impact Area

Source: PhilGIS
Coordinate System: WGS 1984 UTM Zone 51N
Projection: Transverse Mercator
Datum: WGS 1984
Author: Lichel Technologies, Inc.

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Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

Impact Area for Water Quality

FIGURE NO.:

2-40

2.2.2.2 Methodology

2.2.2.2.1 Sampling Methods

On August 28, 2018, LTI conducted water quality sampling, a multi-parameter water quality checker was used to measure in-situ parameters such as pH, temperature, dissolved oxygen (DO), turbidity, conductivity, total dissolved solids and salinity. For the other parameters, grab sampling method was employed. **Table 2-43** shows the sampling method used for water quality.

Sampling was done using sterilized sample containers that were prepared by and obtained from the partner laboratory.

For the sampling in surface water and groundwater, one (1) sample was collected per station. A total of five (5) samples each from surface water and one (1) sample for groundwater were collected.

Each water samples were labeled properly for identification. The label included the name of the water body, sampling station, sampling number, date and time of sampling, and parameter for analysis.

Sampling stations were based on access availability. The stations were also selected due to security reasons as IPs in the area was restricting the access of the sampling sites.

Table 2-43: Methodology for Water Quality Sampling

Parameters	Methodology
Physico-Chemical Test	
Total Suspended Solids (TSS)	Grab sampling
Oil and Grease	Grab sampling
Biochemical Oxygen Demand (BOD)	Grab sampling
Dissolved Oxygen (DO)	Multi-parameter meter
Temperature	Multi-parameter meter
pH	Multi-parameter meter
Total Dissolved Solids (TDS)	Multi-parameter meter
Salinity	Multi-parameter meter
Conductivity	Multi-parameter meter

2.2.2.2.2 Data Collection (Field Activities)

LTI collected grab samples for water quality analysis. The routine data collection involved the following tasks:

- QA/QC of data collected;
- Routine maintenance of equipment;
- Troubleshooting non-routine problems;
- Reporting malfunctions or damage and ensuring the equipment is repaired by the appropriate parties;
- Calibration conducted by EMB-accredited parties;
- Measuring *in-situ* parameters using water quality checker and collecting samples for laboratory analysis for other parameters, ensuring that they are properly logged;
- Bringing samples to laboratory; and
- QA/QC of sample analytical data.

2.2.2.2.3 *In-situ* Measurements

In-situ parameters including pH, temperature, DO, salinity, total dissolved solids, conductivity is measured on-site using the water quality checker which were calibrated by accredited personnel. Certificate of calibration is given as **.**

2.2.2.2.4 Laboratory Analysis

LTI submitted the samples to F.A.S.T. Laboratories in Cagayan de Oro City. The DENR accreditations of the laboratories are attached as **.** Samples were analyzed for various parameters and results presented in **Table 2-44.**

LTI facilitated the transportation of samples along with the chain-of-custody record () and received and checked the results from the laboratories.

Table 2-44: Methodology Used for Laboratory Analysis

Parameters	Methodology
Physico-Chemical Test	
Total Suspended Solids (TSS)	Gravimetric
Oil and Grease	Gravimetric
Biochemical Oxygen Demand (BOD_5)	5-Day BOD Test

2.2.2.2.5 QA/QC

LTI developed a QA/QC procedure for the sampling activity. LTI conducted all sampling activities in accordance with the QA/QC plan. The QA/QC procedures included equipment calibration and maintenance, accomplishment of field data form and chain of custody of samples, field quality control samples, and prevention of sample contamination.

2.2.2.2.6 Equipment Calibration and Maintenance

The equipment used for sampling was calibrated before every sampling event. It was rinsed at each station prior to the collection of samples. This was done by rinsing with water from the same source as the water being collected for the sample.

2.2.2.2.7 Field Data Form and Chain of Custody of Samples

Field data form () and a chain of custody (**COC**) of samples was prepared for each sampling event or whenever samples were delivered to the laboratory. The COC included name of sampler, date of sampling, sample name, parameters for analysis, name of person who delivered the samples and name of person who received the samples. The COC was collected and attached to the sampling report ().

2.2.2.2.8 Prevention of Sample Contamination

Sample contamination was prevented by observing the following precautions:

1. Only laboratory-prepared sample containers were used;
2. Only the recommended type of sample container for each parameter was used **(Annex 3)**;
3. Sample containers were kept in a clean location.
4. All sampling instrument were cleansed before and after using and as prescribed by the manufacturer.
5. Samples were never left to stand in the sun for a long time.

6. Samples were delivered to the laboratory on the same day, which is less than the holding time of 24 hours.
7. During transportation of samples to the laboratory, it was stored in the proper temperature (20^0C) for preservation.

2.2.2.3 Baseline Water Quality

2.2.2.3.1 Surface Water Quality

Baseline data gathering and field work were conducted by Lichel Technologies, Inc. (LTI) on August 10 and 28, 2018. However, sampling was also conducted on approximately the same area for the Pulangi V Hydro Electric Power Plant (HEPP) project on September 25, 2010 and June 1, 2011 to determine the water quality conditions of the Project area.

Five surface water sampling stations and one ground water sampling station were established by LTI along Pulangi River. Specific geographical coordinates of stations were obtained using GPS and the water quality in-situ measurements in each station were done using a water quality checker and collected water samples were analyzed through DENR-accredited laboratories.

Four (4) sampling stations were established for the Pulangi V HEPP project, the locations of which are illustrated in **Figure 2-39.**

Based on DENR's DAO 2016-08, Pulangi River was classified under Class A as presented in **Table 2-45** below. Due to security reasons, the other corresponding wells and tributaries were unsampled and were not classified under DAO 2016-08. The DENR Water Quality Guidelines for surface water quality analysis are shown in **Table 2-46.**

Table 2-45: Baseline Sampling Stations

Station Code	Intended Beneficial Use (DENR DAO 2016-08)	Date of Sampling	Location	Coordinates	
				Latitude	Longitude
PFWQ1	Class A - Public Water Supply Class II-Intended as sources of water supply requiring conventional treatment to meet latest PNSDW	Aug 28, 2018	Pulangi River - Barangay Tangkulan	07°25'47.79"	125°02'15.80"
PFWQ2		Aug 28, 2018	Pulangi River – Barangay Miaray	07°35'29.00"	125°03'27.98"
PFWQ3		Aug 28, 2018	Pulangi River – Baragay San Vicente	07°35'31.25"	125°03'27.58"
PFWQ4		Aug 28, 2018	Pulangi River – Barangay Camp I	07°43'16.74"	125°00'55.01"
PFWQ5		Aug 28, 2018	Pulangi River – Barangay Lumbo	07°54'56.50"	125°02'55.71"
W1		Sept 5, 2010	Pulangi River – Upstream Barangay Kitaihon	07˚36'38.4"	125˚03'31.7"
W2		Sept 5, 2010	Pulangi River – Midstream Barangay Natulongan	07˚31'35.9"	125˚03'03.0"
W3		Jul 1, 2011	Pulangi River – Downstream	07˚23'16.9"	125˚01'56.9"

Station Code	Intended Beneficial Use (DENR DAO 2016-08)	Date of Sampling	Location	Coordinates	
				Latitude	Longitude
			Barangay Lama-Lama – Sitio Pulangi V		
W4		Jul 1, 2011	Culaman River Before diverging with Pulangi River	07˚23'16.2"	125˚01'58.0"

Table 2-46: Surface Water Sampling Parameters and DENR Water Quality Guidelines

Parameter	Unit	DENR Guidelines DAO 2016-8 for Class A
Total Suspended Solids (TSS)	mg/L	50
Oil and Grease	mg/L	1
Biochemical Oxygen Demand (BOD)	mg/L	3
Dissolved Oxygen (DO)	mg/L	5.0 (minimum)
Temperature	°C	26-30 (b)
pH	-	6.5-8.5
Total Dissolved Solids (TDS)	ppm	-
Salinity	ppb	-
Conductivity	µS/cm	-

Notes:

(a) Samples shall be taken from 9:00 AM to 4:00 PM

(b) The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment.

2.2.2.3.2 Groundwater Sampling

One (1) sampling station was identified for the sampling of groundwater quality. The water quality measurements for *In-situ parameters* in each station were done with the use of the water quality checker and grab samples for other parameters were taken to the Laboratory for analysis. The groundwater sampling stations are presented in **Table 2-47.** The Groundwater Sampling Parameters, DENR Water Quality Guidelines and DOH Philippine National Standards for Drinking Water of 2007 and 2017 are shown in **Table 2-48.**

Table 2-47: Description of Groundwater Sampling Stations

Station Code	Intended Beneficial Use (DENR DAO 2016-08)	Date of Sampling	Location	Geographical Coordinates	
				Latitude	Latitude
PGWQ1	Class B – Bathing and Other Primary Contact Recreation Class C – Irrigation, Fish Culture, Livestock Watering	Aug 28, 2018	Barangay Miaray, Dangcagan	7° 34' 52.02"	125° 03' 03.50"

Table 2-48: Groundwater Sampling Parameters and DENR Water Quality Guidelines

Parameter	Unit	DENR Guidelines DAO 2016-08 for Class B	DENR Guidelines DAO 2016-08 for Class C	DOH Philippine National Standards for Drinking Water AO 2007-12	DOH Philippine National Standards for Drinking Water AO 2017-10
Total Suspended Solids (TSS)	mg/L	65	80	-	-
Oil and Grease	mg/L	1	2	-	-
Biochemical Oxygen Demand (BOD)	mg/L	-	-	-	-
Dissolved Oxygen (DO)	mg/L	-	-	-	-
Temperature	°C	26-30[(b)]	25-31[(b)]	-	-
pH	-	6.5-8.5	6.5-9.0	6.5-8.5	6.5-8.5
Total Dissolved Solids (TDS)	ppm	-	-	500	600
Salinity	ppb	-	-	-	-
Conductivity	µS/cm	-	-	-	-

Notes:
(a) Samples shall be taken from 9:00 AM to 4:00 PM
(b) The natural background temperature as determined by EMB shall prevail if the temperature is lower or higher than the WQG; provided that the maximum increase is only up to 10 percent and that it will not cause any risk to human health and the environment.

2.2.2.4 Sampling Results

The weather condition during sampling and for the past 24 hours was overcast and with intermittent rains, respectively. The temperature ranged from 28.2°C to 31.0°C.

2.2.2.4.1 Surface Water

The results for the surface water sampling are presented in **Table 2-49.** The surface water bodies are classified by the Environmental Management Bureau of the DENR (EMB-DENR) as Class A freshwaters, which include fishery water, recreational water for boating, and/or industrial water for manufacturing processes. Thus, the results from the sampling were compared with the DENR Water Quality Guidelines for Class A freshwater, based on the DENR Administrative Order No. 2016-08 (DAO 2016-08) Standards. **Table 2-50** shows the results of the surface water sampling conducted for the Pulangi V HEPP.

Table 2-49: Surface Water Sampling Results (LTI, 2018)

Parameter	Unit	DENR Water Quality Guidelines (DAO 2016-08) for Class A	PFWQ1	PFWQ2	PFWQ3	PFWQ4	PFWQ5
Date	mm/dd/yy		08/28/2018	08/28/2018	08/28/2018	08/28/2018	08/28/2018
Time	24-hr		10:56	11:20	11:41	2.25	3:40
Temperature	°C	26-30	27.49	28.50	27.93	27.29	28.52
pH	-	6.5-8.5	7.89	7.96	7.98	8.09	8.05
TSS	mg/L	50	30	29	27	18	15

Parameter	Unit	DENR Water Quality Guidelines (DAO 2016-08) for Class A	PFWQ1	PFWQ2	PFWQ3	PFWQ4	PFWQ5
TDS	Ppm	600*	136	137	137	128	129
Salinity	Ppb	-	0.13	0.13	0.13	0.12	0.12
Conductivity	µS/cm	-	273	274	274	256	259
Oil & Grease	mg/L	1	1	2	2	2	2
DO	mg/L	5.0 (min)	5.24	6.06	5.27	5.75	4.55
BOD_5	mg/L	3	4	<1	1	<1	<1

*DOH Philippine National Standards for Drinking Water AO 2017-10

Table 2-50: Surface Water Sampling Results (Pulangi V Study, 2011)

Parameters	W1	W2	W3	W4
Date	Sept 5, 2010	Sept 5, 2010	July 1, 2011	July 1, 2011
Color (PCU)	15	20	175	175
Turbidity (NTU)	8.11	7.98	359	297
TSS (mg/L)	159	165	143	70.0
Oil & Grease (mg/L)	0.8	1.6	2.0	2.0
Chloride (mg/L)	12	18	<1.0	<1.0
Sulfate (mg/L)	1.91	2.95	27.3	22.7
Total Hardness (mg/L)	78	79	108	66
Nitrate (mg/L)	0.094	0.0110	17.6	16.7

2.2.2.4.1.1 Temperature

As shown in **Figure 2-41,** the recorded temperatures for stations PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 were 27.49°C, 28.50°C, 27.93°C, 27.29°C, and 28.52°C, respectively. All surface water sampling stations had temperature values that are within the Water Quality Guidelines, 26-30°C.

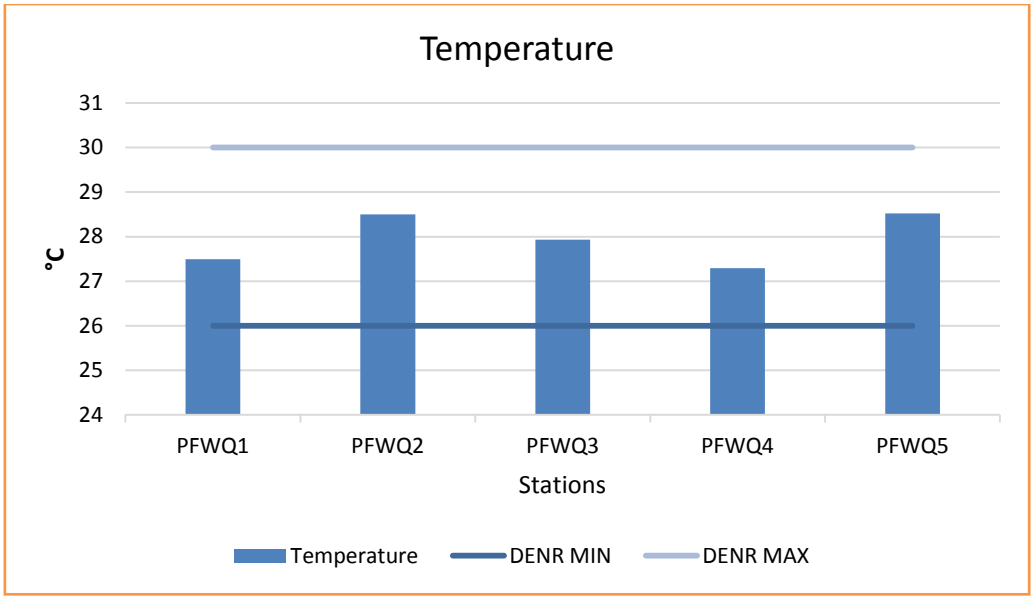


Figure 2-41: Temperature (FW, LTI 2018)

2.2.2.4.1.2 Hydrogen-ion Concentration (pH)

The recorded pH values from the surface water sampling stations, PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 were 7.89, 7.96, 7.98, 8.09 and 8.05, respectively (**Figure 2-42**). All stations were within the guidelines.

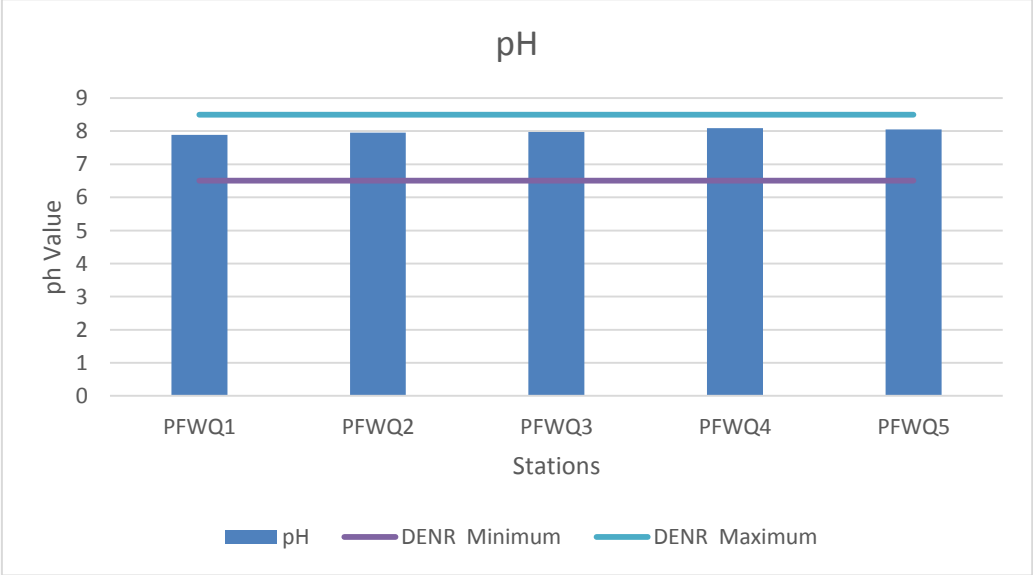


Figure 2-42: pH (FW, LTI 2018)

2.2.2.4.1.3 Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

The recorded TSS from the surface water bodies were within DENR standards with concentrations of 30 mg/L, 29 mg/L, 27 mg/L, 18 mg/L and 15 mg/L for sampling stations PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 (**Figure 2-43**).

The results in **Figure 2-44** shows that TDS concentrations were 136 mg/L, 137 mg/L, 137 mg/L, 137 mg/L, 128 mg/L and 129 mg/L for sampling stations FWQ1, FWQ2, FWQ3, and FWQ4, respectively.

There is no DENR Water Quality Guidelines for TDS. However, there is a standard under the PNSDW for TDS with a standard of 600 ppm.

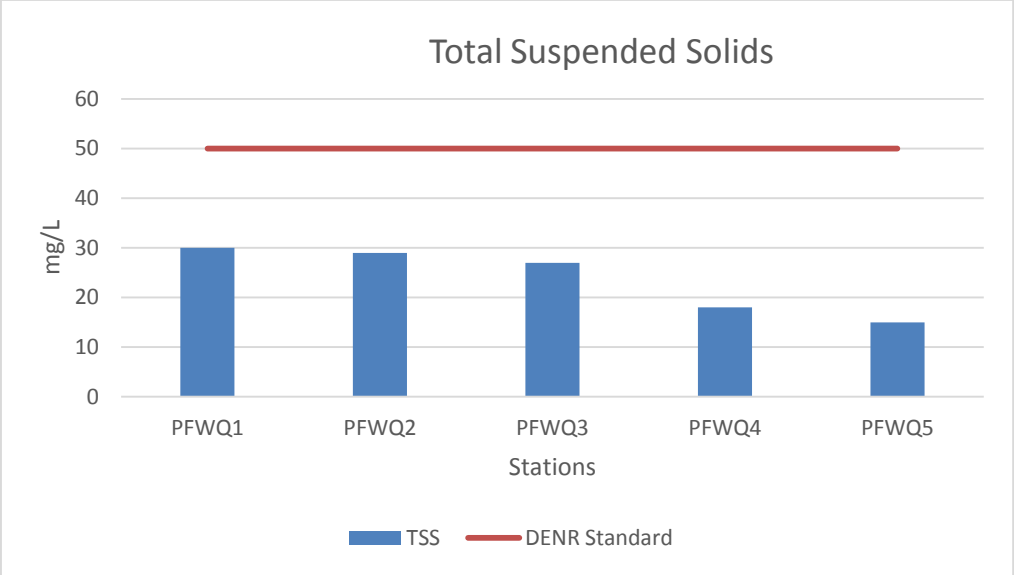


Figure 2-43: Total SuspendedSolids (FW, LTI 2018)

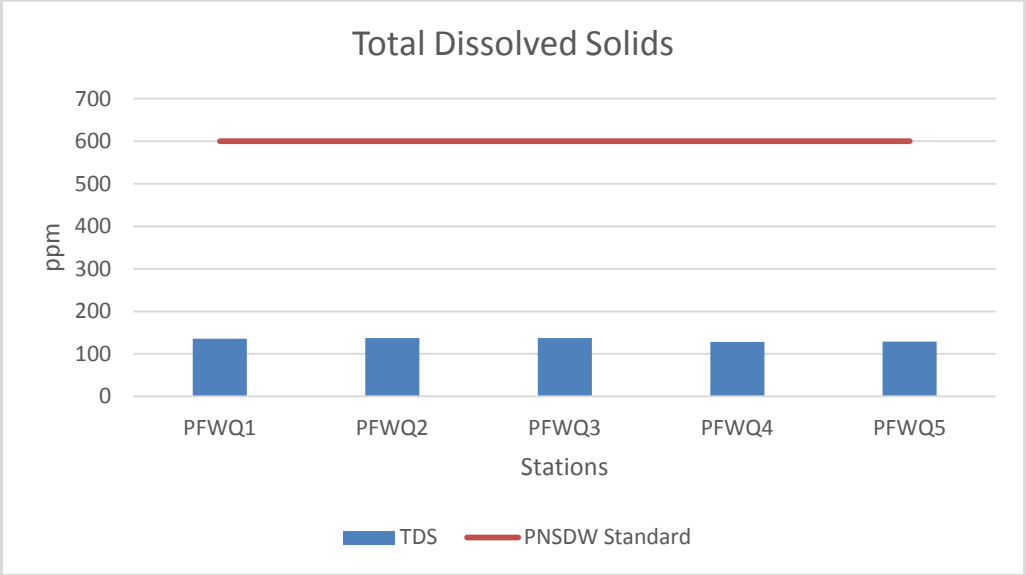


Figure 2-44: Total Dissolved Solids (FW, LTI 2018)

2.2.2.4.1.4 Salinity and Conductivity

The salinity of sampling stations PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 were 0.13 ppb, 0.13 ppb, 0.13 ppb, 0.12 ppb and 0.12 ppb, respectively.

The conductivity of sampling stations PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 were 273 µS/cm, 274 µS/cm, 274 µS/cm, 256 µS/cm and 259 µS/cm, respectively.

Salinity and conductivity are indicators of the electrical conductivity of water. **Figure 2-45 and Figure 2-46** present the graphical results for the salinity and conductivity, respectively.

There is no DENR Water Quality Guidelines for salinity and conductivity.

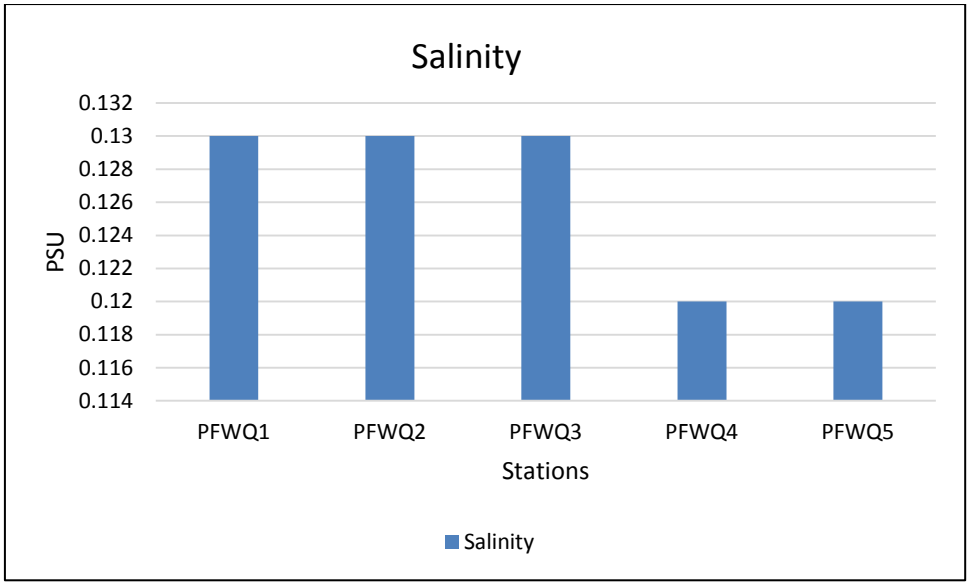


Figure 2-45: Salinity (FW, LTI 2018)

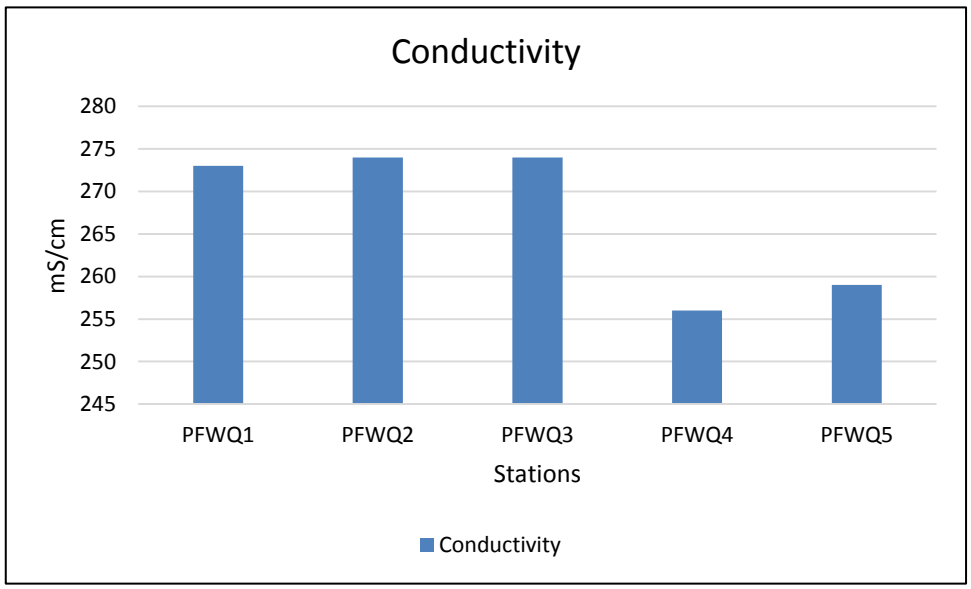


Figure 2-46: Conductivity (FW, LTI 2018)

2.2.2.4.1.5 Oil and Grease

Oil and grease measurements for sampling stations PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 were 1 mg/L, 2 mg/L, 2 mg/L, 2 mg/L and 2 mg/L, respectively (). The DENR Water Quality Guidelines for oil and grease as specified in DAO 2016-08 is 1 mg/L. With the exception of PFWQ1, the remaining surface water sampling stations exceeded DENR Water Quality Guidelines. **Figure 2-47** presents the graphical results for oil and grease.

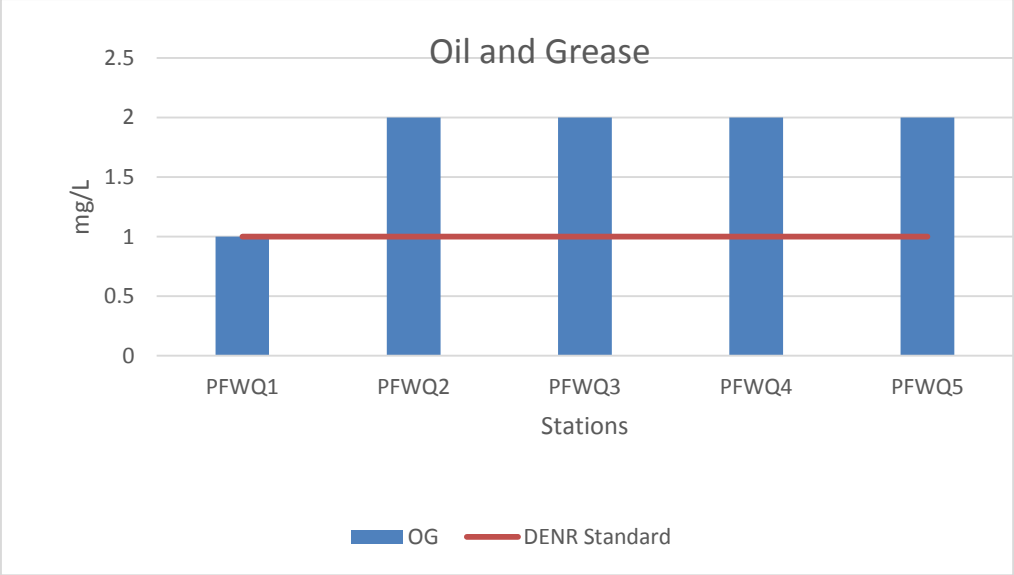


Figure 2-47: Oil and Grease (FW, LTI 2018)

2.2.2.4.1.6 Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD_5)

As shown in **Table 2-49**, the DO of sampling stations PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 were 5.24 mg/L, 6.06 mg/L, 5.27 mg/L, 5.75 mg/L and 5.55 mg/L, respectively. The values for all stations were above the DENR Water Quality Guideline for DO which requires a minimum of 5.0 mg/L.

The BOD_5 level of sampling stations PFWQ1, PFWQ2, PFWQ3, PFWQ4 and PFWQ5 were 4 mg/L, <1 mg/L, <1 mg/L, 1 mg/L, <1 mg/L and 1 mg/L, respectively. The BOD values for one (1) station, PFWQ1, was tested to have a concentration of 4mg/L above the DENR Water Quality Guideline for Class A of 3 mg/L. The remaining stations were tested to be compliant with the DENR Water Quality Guidelines for Class A Fresh Waters of 3 mg/L.

Figure 2-48 and **Figure 2-49** present the graphical results for the DO and BOD_5, respectively.

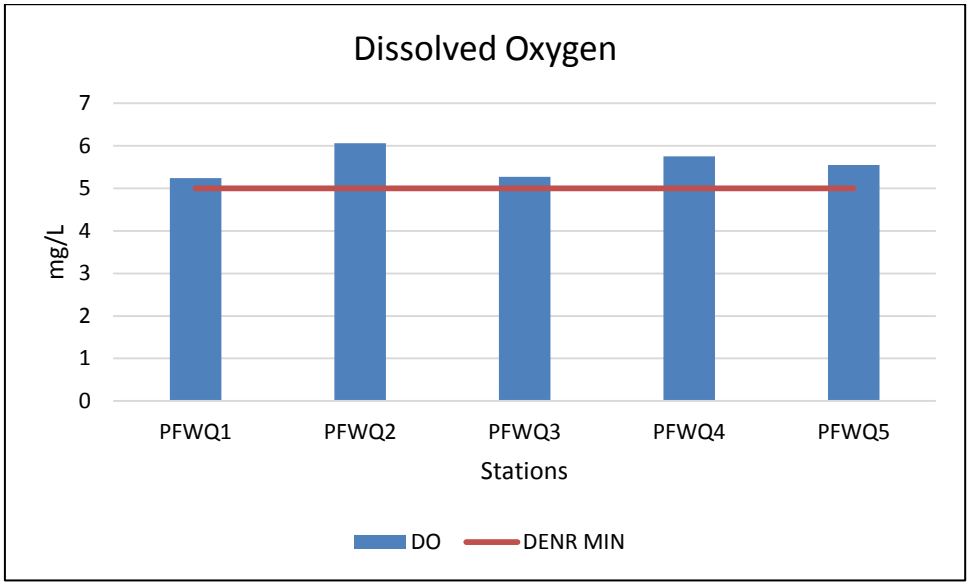


Figure 2-48: Dissolved Oxygen (FW, LTI 2018)

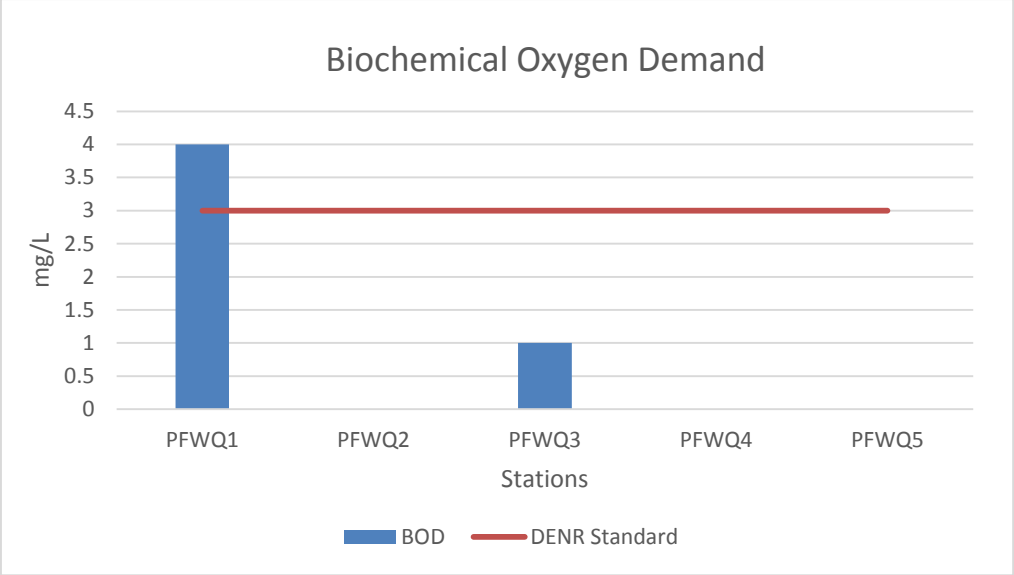


Figure 2-49: BOD_5 (FW, LTI 2018)

2.2.2.5 Groundwater

One (1) sampling station identified for the sampling of groundwater quality. The water quality measurements in each station were done *in situ* and samples collected for other parameters were brought to DENR-accredited laboratory for analysis.

The sampling results for the groundwater sampling are presented in **Table 2-51**. Results are compared to the DENR DAO 2016-08 Class A and B and Philippine National Standard for Drinking Water (PNSDW).

Table 2-51: Groundwater Sampling Results

Parameter	Unit	DENR Guidelines DAO 2016-08 Class B	DENR Guidelines DAO 2016-08 Class C	PNSDW 2007	PNSDW 2017	PGWQ1
Date	mm/dd/yy					8/28/2018
Time	24-hr					14:54
Temperature	°C	26-30	25-31	-	-	27.34
pH	-	6.5-8.5	6.5-9.0	6.5-8.5	6.5-8.5	8.11
TSS	mg/L	65	80	-	-	4
TDS	ppm	-	-	500	600	345
Salinity	ppb	-	-	-	-	0.33
Electrical Conductivity	µS/cm	-	-/	-	-	692
Oil & Grease	mg/L	1	2	**-**	-	10
DO	mg/L	-	-	-	-	0.30
BOD_5	mg/L	-	-	-	-	2

2.2.2.5.1.1 Temperature

As shown in **Table 2-51**, the recorded temperatures for sampling station for PGWQ1, 27.34 °C and is compliant to DENR WQG.

2.2.2.5.1.2 Hydrogen-ion Concentration (pH)

The pH for sampling station PGWQ1 was 8.11 (**Table 2-51**). The pH value was detected to be compliant with the DENR WQG and the PNSDW Standards.

2.2.2.5.1.3 Total Suspended Solids (TSS) and Total Dissolved Solids (TDS)

The TSS values for PGWQ1 was 4 mg/L which is below the DENR WQG of 65 mg/L and 80 mg/L for Class B & C, respectively. There is no water quality guideline for TSS in PNSDW.

While TDS values obtained from PGWQ1 was 345 ppm (**Table 2-51**). There is no DENR WQG for TDS.

2.2.2.5.1.4 Salinity and Electrical Conductivity

The salinity and electrical conductivity for PGWQ1 were 0.33 ppb and 692 µS/cm, respectively (**Table 2-51**). There are no DENR WQG and PNSDW Standards for salinity and electrical conductivity.

2.2.2.5.1.5 Oil and Grease

Oil and grease were tested to be 10 mg/L for PGWQ1 which is above the DENR WQG of 1 mg/L for Class B and 2 mg/L for Class C (**Table 2-51**).

2.2.2.5.1.6 Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD_5)

The DO level of PGWQ1 was 0.3 mg/L and BOD_5 level was 2 mg/L (**Table 2-51**), there is no DENR WQG and PNSDW Standards for DO and BOD in groundwater.

2.2.2.6 Key Environmental Impacts and Proposed Mitigating Measures

2.2.2.6.1 Construction Phase

Construction activities of the dam include possible discharges that would degrade the water quality. These construction activities would include wastewater that would contain concentrations of suspended solids, used oil/oil contaminated equipment, and possible domestic waste. As shown in **Table 2-49** and **Table 2-51**, the sampling results identified three (3) surface water stations and one (1) ground water station to be tested at concentrations above DENR Water Quality Guidelines for oil and grease. The results also identified one (1) surface water station above the DENR Water Quality Guidelines for BOD. **Table 2-52** presents the proposed mitigating measures.

Soil erosion will happen during construction due to slope and geological conditions in the watershed area and service areas. Further, the removal of the vegetation and excavation of soil to give way on the construction of dams, reservoir, powerhouse and access roads will generate soil erosion and will increase the sedimentation and siltation of the downstream river system. During construction the disturbed area will be the source of sediment, as construction will need to be undertaken within the channel bed.

2.2.2.6.2 Operation Phase

During project operations, water quality may be affected due to the following:

- Increased of soil and liquid domestic wastes from permanent structures
- Change in water quality due to improper waste disposal
- Increase in vehicle activity which may lead to increase in oil and grease in water bodies.
- Wastes from feeds and excrements in Aqua culture

Overall, the major water quality impact may be summarized for the two (2) phases of the component which is the construction and operation phase. The construction phase involves the increase of sediments and silt in the river due to soil erosion, increase solid and liquid waste from temporary workers and buildings and accidental oil spill from increased oil generation. The operation phase involves impacts such as increased solid and liquid wastes from the permanent structures after the completion of the dam and the possible wastes from feed and excrements in aqua culture.

Table 2-52: Summary of the Significant Impacts and Mitigation Measures for Degradation of Water Quality

Parameter	PFWQ1	PFWQ2	PFWQ3	PFWQ4	PFWQ5
TSS	Baseline Data: 30 mg/L Construction Phase: Increased TSS due to sedimentation and siltation due to soil erosion Operation Phase: TSS may slightly decrease as soil erosion preventative measures should be applied	Baseline Data: 29 mg/L Construction Phase: TSS may remain affected as construction of the dam and powerhouse are located near PFWQ1 Operation Phase: TSS may be unaffected	Baseline Data: 27 mg/L Construction Phase: TSS may remain affected as construction of the dam and powerhouse are located near PFWQ1 Operation Phase: TSS may be unaffected	Baseline Data: 18 mg/L Construction Phase: TSS may remain affected as construction of the dam and powerhouse are located near PFWQ1 Operation Phase: TSS may be unaffected	Baseline Data: 15 mg/L Construction Phase: TSS may remain affected as construction of the dam and powerhouse are located near PFWQ1 Operation Phase: TSS may be unaffected
BOD	Baseline Data: 4 mg/L Construction Phase: Tested levels of BOD may increase as solid and liquid waste from temporary workers and structures Operation Phase: Slight decrease in BOD levels as temporary workers and structures taken down and permanent structures are completed.	Baseline Data: <1 mg/L Construction Phase: Increased BOD may only be applicable from solid waste be nearby residents Operation Phase: No expected increase in BOD unless from solid waste from nearby residents.	Baseline Data: 1 mg/L Construction Phase: Increased BOD may only be applicable from solid waste be nearby residents Operation Phase: No expected increase in BOD unless from solid waste from nearby residents.	Baseline Data: <1 mg/L Construction Phase: Increased BOD may only be applicable from solid waste be nearby residents Operation Phase: No expected increase in BOD unless from solid waste from nearby residents.	Baseline Data: <1 mg/L Construction Phase: Increased BOD may only be applicable from solid waste be nearby residents Operation Phase: No expected increase in BOD unless from solid waste from nearby residents.

Parameter	PFWQ1	PFWQ2	PFWQ3	PFWQ4	PFWQ5
Oil and Grease	Baseline Data: 1 mg/L Construction Phase: Increased OG may be applicable from a higher waste oil generation from construction of structures and oil containing equipment Operation Phase: Limited waste oil generation may attribute to lower OG concentrations. Traces of OG concentrations may be attributed to spill from boats in the area.	Baseline Data: 2 mg/L Construction Phase: OG concentrations are higher compared to the PFWQ1 which may be due to the residents located in the area which may have caused an accidental discharge of oil and grease to the water. Operation Phase: Increase of OG may be unaffected by the operation of the dam	Baseline Data: 2 mg/L Construction Phase: OG concentrations are higher compared to the PFWQ1 which may be due to the residents located in the area which may have caused an accidental discharge of oil and grease to the water. Operation Phase: Increase of OG may be unaffected by the operation of the dam	Baseline Data: 2 mg/L Construction Phase: OG concentrations are higher compared to the PFWQ1 which may be due to the residents located in the area which may have caused an accidental discharge of oil and grease to the water. Operation Phase: Increase of OG may be unaffected by the operation of the dam	Baseline Data: 2 mg/L Construction Phase: OG concentrations are higher compared to the PFWQ1 which may be due to the residents located in the area which may have caused an accidental discharge of oil and grease to the water. Operation Phase: Increase of OG may be unaffected by the operation of the dam

2.2.3 Freshwater Ecology

2.2.3.1 Introduction

Hydropower theoretically, does not pollute the water or the air. However, hydropower facilities can have large environmental impacts by changing the environment and affecting land use, homes, and natural habitats in the dam area. Also, the construction phase of the dam and its adjunct facilities could have a short term negative effect to the environment. Even after the construction phase, activities related to the maintenance and operation of the dam, could have low but recurrent negative impact.

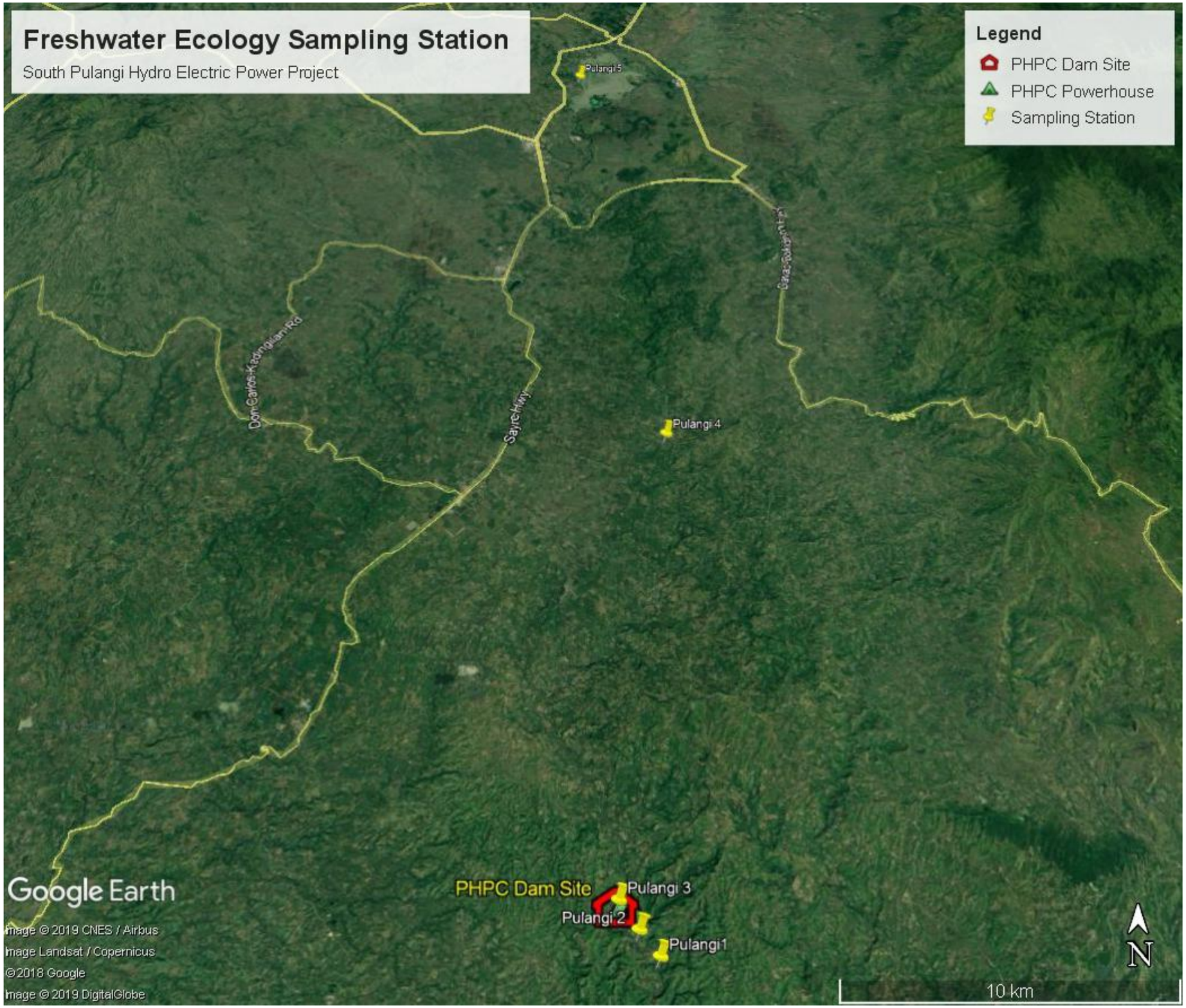
2.2.3.1.1 Methodology

Sampling Sites

The sampling stations have been designated based on the South Pulangi HEPP Project plan, from the upstream location of the proposed dam to the downstream. With the permission from the local communities in the various sites, aquatic biology data gathering was done on each of the sites below:

Table 2-53: Freswater Ecology Sampling Stations

Sampling Sites	Coordinates	Remarks
Pulangui 1	N 7.41582 E 125.048917	3 km downstream from from Pulangi 3 site; 20 august 2018,surface current estimated at 2m/sec;; water murky
Pulangui 2	N 7.422467 E 125.043378	1.5 km downstream from Pulangi 3 site; 20 august 2018,surface current estimated at 2m/sec; water murky
Pulangui 3	N 7.430147 E 125.03781	Proposed site of the dam structure and the power plant ; 20 august 2018,surface current estimated at 2m/sec; water murky; upstream to this would be the start of the projected submerged area
Pulangui 4	N 7.59157 E 125.05748	Midway between sites Pulangi 3 and Pulangi 5 ; vicinity of Dangcala; 20 august 2018,surface current estimated at 2m/sec; river relatively shallower and narrower with some area where big stones are visible above water; water murky; upstream portion of the projected submerged area
Pulangui 5	N 7.806660 E 125.024419	The current Pulangi Lake at Maramag water less murky than the other sites



Lichel Technologies, Inc. Unit 1403 Prestige Tower Condominium F. Ortigas, Jr. Road, Ortigas Center, Pasig City	FIGURE TITLE : **Freshwater Ecology Sampling Station**	FIGURE NO.: **2-49**

Plate 2: Freswater Ecology Station Pulangi 1

Plate 3: Freswater Ecology Station Pulangi 2

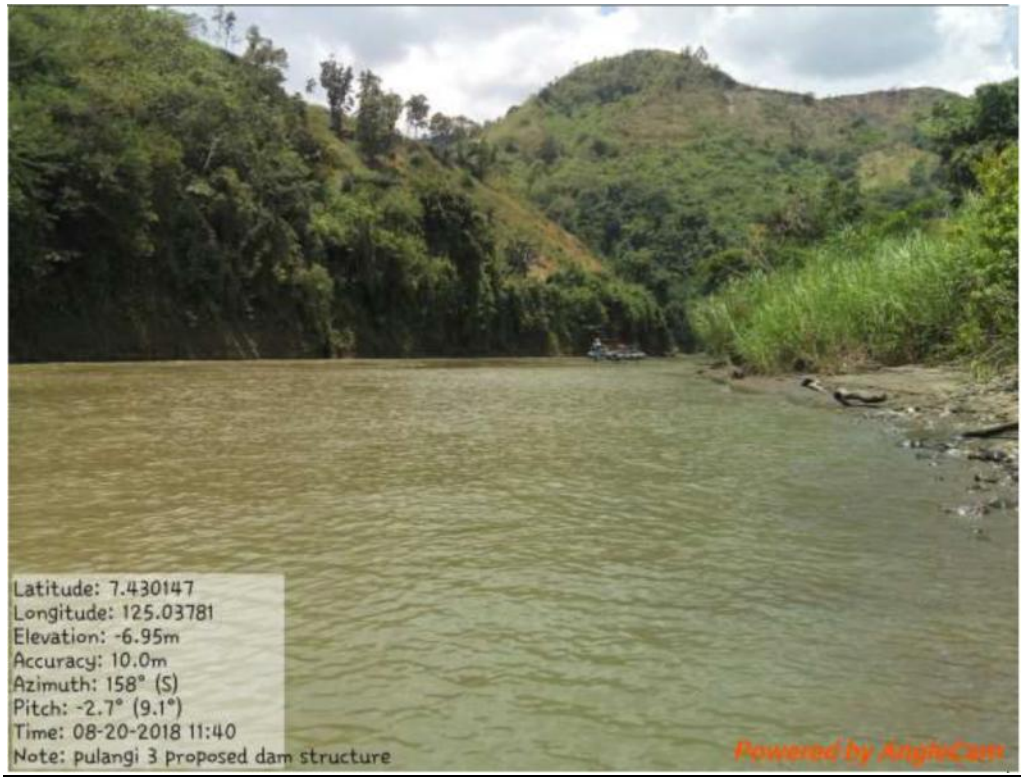


Plate 4: Freswater Ecology Station Pulangi 3

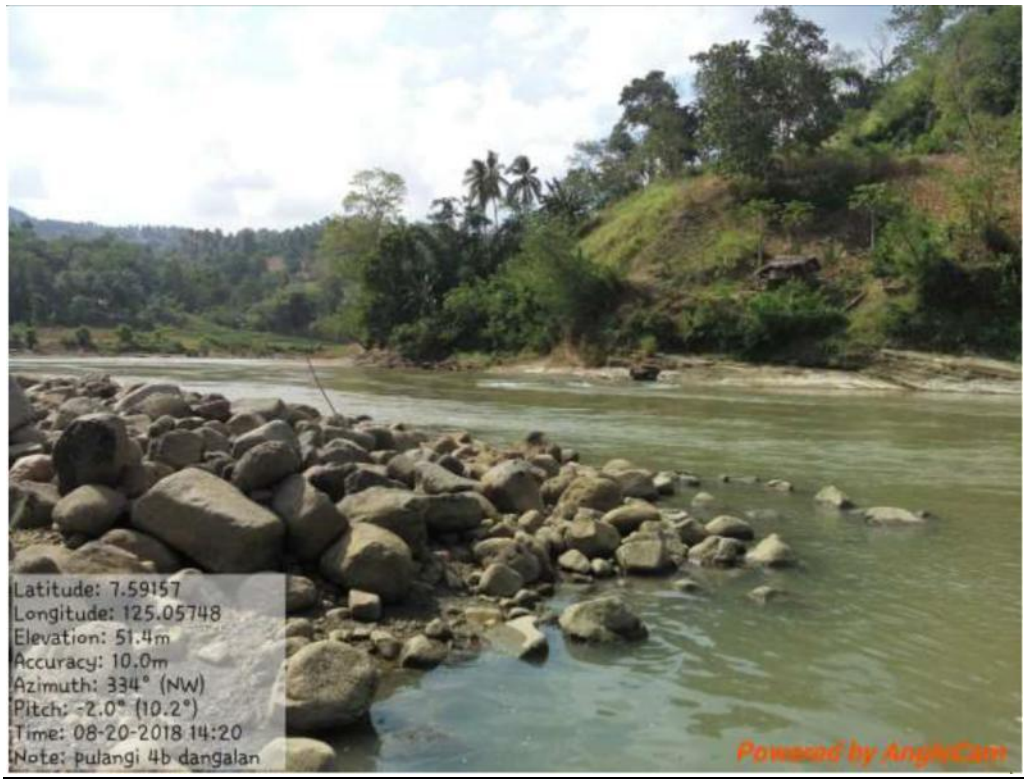


Plate 5: Freswater Ecology Station Pulangi 4

Plate 6: Freswater Ecology Station Pulangi 5

For each site, a qualitative assessment of the riverbank was also made with reference to channel characteristics (i.e.run, riffle, pool; streambank slope; erosion / blockages; vegetation; human habitation, etc.). The characteristics were noted along a 50 m stretch of riverbank,

RCE: Riparian, Channel, and Environmental Inventory (Petersen, 1992)

Determine the condition of the stream CHANNEL AND RIPARIAN ZONE at which you are standing and up to 50 m upstream and downstream. Estimate the average condition over that distance and select ONE of the four scores for each characteristic. If the appraisal is accurate for a longer stream reach, record that distance on item marked STREAM LENGTH.

	Score
1. Land-use pattern beyond the immediate riparian zone	
Undisturbed, consisting of forest, natural wetlands, bog and/or mires	30
Permanent pasture mixed with woodlots and swamps, few row crops	20
Mixed row crops and pasture	10
Mainly row crops	1
2. Width of riparian zone from stream edge to field	
Marshy or woody riparian zone >30 m wide	30
Marshy or woody riparian zone varying from 5 to 30 m wide	20
Marshy or woody riparian zone 1-5 m	5
Marshy or woody riparian zone absent	1
3. Completeness of riparian zone	
Riparian zone intact without breaks in vegetation	30
Breaks occurring at intervals of >50 m	20
Breaks frequent with some gullies and scars every 50 m	5
Deeply scarred with gullies all along its length	1
4. Vegetation of riparian zone within 10 m of channel	
>90% plant density of non-pioneer trees or shrubs, or native marsh plants	25
Mixed pioneer species along channel and mature trees behind	15
Vegetation of mixed grasses and sparse pioneer tree or shrub species	5
Vegetation consisting of grasses, few tree species	1
5. Retention devices	
Channel with rocks and old logs firmly set in place	15
Rocks and logs present by back filled with sediment	10
Retention devices loose; moving with floods	5
Channel of loose sandy silt; few channel obstructions	1
6. Channel structure	
Ample for present and annual peak flows, width/depth <7	15
Adequate, overbank flows rare, W/D 8 to 15	10
Barely contains present peaks, W/D 15 to 25	5
Overbank flows common, W/D >25 or stream is channelized	1
7. Channel sediments	
Little or no channel enlargement resulting from sediment accumulation	15
Some gravel bars of coarse stones and well-washed debris present, little silt	10
Sediment bars of rocks, sands and silt common	5
Channel divided into braids or stream is channelized	1
8. Stream-bank structure	
Banks stable, of rock and soil held firmly by grasses, shrubs and tree roots	25
Banks firm but loosely held by grass and shrubs	15
Banks of loose soil held by a sparse layer of grass and shrubs	5
Banks unstable, of loose soil or sand easily disturbed	1

9. Bank undercutting	
Little or none evident or restricted to areas with tree root support	20
Cutting only on curves and at constrictions	15
Cutting frequent, undercutting of banks and roots	5
Severe cutting along channel, banks falling in	1
10. Stony substrate; feel and appearance	
Stones clean, rounded without sharp edges; may have blackened color	25
Stones without sharp edges and with slight sand, silt, gritty feel	15
Some stones with sharp edges, obvious gritty cover	5
Stones bright; silt, grit cover and sharp edges common	1
11. Stream bottom	
Stony bottom of several sizes packed together, interstices obvious	25
Stony bottom easily moved, with little silt	15
Bottom of silt, gravel and sand, stable in places	5
Uniform bottom of sand and silt loosely held together, stony substrate absent	1
12. Riffles and pools, or meanders	
Distinct, occurring at intervals of 5-7x stream width	25
Irregularly spaced	20
Long pools separating short riffles, meanders absent	5
Meanders and riffles/pools absent or stream channelized	1
13. Aquatic vegetation	
When present consists of moss and patches of algae	15
Algae dominant in pools, vascular plants along edge	10
Algal mats present, some vascular plants, few mosses	5
Algal mats cover bottom, vascular plants dominate channel	1
14. Detritus	
Mainly consisting of leaves and wood without sediment	25
Leaves and wood scarce; fine flocculent organic debris without sediment	10
No leaves or woody debris; coarse and fine organic matter with sediment	5
Fine, anaerobic sediment, no coarse debris	1
Total	_____

RCE Scoring

Class	Score	Evaluation	Recommended action
I	261-320	Excellent	Bio-monitoring and protection of existing status
II	201-260	Very good	Selected alterations and monitoring for changes
III	141-200	Good	Minor alterations needed
IV	81-140	Fair	Major alterations needed
V	14-80	Poor	Complete structural reorganization

2.2.3.2 Freshwater Biota

General consideration

Sampling was done on each site taking into consideration accessibility and feasibility of employing our intended sampling procedures. Specific deviations in each site are here also indicated.

2.2.3.2.1 Plankton

Zooplankton and phytoplankton samples were collected from the water column using a plankton net of 80 µm mesh size. Approximately 50 liters of water were collected, preferably from slow moving portions of the stream. Samples (approximately 50 ml) were immediately placed in plastic leak-proof bottles, 7ml of 35% buffered formalin and 1 drop of concentrated rose Bengal solution added.

Plankton identification and counts were determined in the laboratory. Each sampled water was tapped with additional water to make 100 ml. From this 100 ml sample, a 1 ml sub-sample was taken after thorough mixing for plankton identification and counting.

2.2.3.2.2 Macro-invertebrates

Where the substratum is composed of stones, attached algae were scraped using a plastic brush with very pliable bristles, from a 10 m riverbank transect for an approximate total of 1 sq m of surface area of stones and other suitable substrates (leaf litter, wood, etc).

In sandy or muddy substrates, Approximately 1 sq m (cumulative) of substrate (taken 1 inch deep) was passed through a 1 mm sieve.

All samples were preserved in 70% alcohol.

A mosquito net was used as an improvised seine net to cover an area of 20 m^2 suitable riverbank.

2.2.3.2.3 Fish Fauna and other macro-biota

When and where ever it is possible, available local fishermen were contacted and instructed to do line or cast net fishing.

2.2.3.3 Results and Discussion

2.2.3.3.1 Sampling Sites

Sampling was done in the third week of August 2018. The rainy season has already officially begun and afternoon to early evening rains were experienced during this occasion. The weather was relatively fair during the actual field work at the sampling sites. The data gathered could be regarded as part of the rainy season data.

Due to cultural considerations, sampling was somewhat restricted to some barangays that do have jurisdiction on a particular portion of the river. Fishing was done only with the use of a fishnet (mesh size 4 cm) in the deeper parts of the river. The mosquito net was used along the riverbanks. The four local guides and the boat operator gave information on the fishes caught along the sites.

No fishing was done in the site at Pulangi Lake, as our guide from Pulangi Power stated that the area is restricted.

2.2.3.3.2 Assessment of Riparian Zone

Based on the RCE scoring, Site Pulangi 1, located downstream to the proposed dam structure has the highest score with a descriptive quality of “very good”. The geographical terrain may could have made the area relatively inaccessible and not conducive to human habitation at present.

Sites Pulangi 2 and 3, approximately within the area where the dam structure would be located have an RCE rating of “Good”. The riverbanks in the two areas appear to have been subjected to human disturbances, and one or two huts were observed standing about >100 m from the riverbanks. The terrain in the two sites still appears to permit few options for agriculture, preserving existing secondary riparian growth.

The more upstream Pulangi 4 site between Dancagan and Kitaotao, has the lowest RCE. The banks are usually lower and it is presumed that the river width greatly increases during period of flooding.

The original RCE Inventory is a 16-variable assessment tool for the physical and biological condition of small streams in the lowland, agricultural landscape. In this study we have modified it by removing two components – macro-invertebrates and fishes, as these are covered in a separate data.

In the Philippines, the use of RCE, in toto or modified, in assessing rivers is gaining ground. Lately, RCE scores were found to be correlated to macro-invertebrate density in the following areas: Gibong River (Peligro & Jumawan, 2015), in Malapatan, Sarangani (Dice et al., 2014), and in Tubay, Agusan del Norte (Fajardo & Jumawan, 2015). In the latter, the highest RCE scores were computed from areas with better vegetation cover.

RCE Parameters	Pulangi 1	Pulangi 2	Pulangi 3	Pulangi 4
1. Land-use pattern beyond the immediate riparian zone	20	20	10	10
2. Width of riparian zone from stream edge to field	30	30	20	5
3. Completeness of riparian zone	20	20	20	5
4. Vegetation of riparian zone within 10 m of channel	5	5	5	1
5. Retention devices	1	1	1	1
6. Channel structure	15	15	15	15
7. Channel sediments	10	10	10	5
8. Stream-bank structure	25	15	15	5
9. Bank undercutting	20	15	15	5
10. Stony substrate; feel and appearance	15	15	15	5
11. Stream bottom	15	15	5	5
12. Riffles and pools, or meanders	20	20	20	20
13. Aquatic vegetation	1	1	1	1
14. Detritus	5	5	5	5
Total	**202**	**187**	**157**	**88**

2.2.3.3.3 Biota of the sampling sites

Plankton

Table 2-54 bel ow presents the plankton taxa collected in the stations.

Table 2-54: Plankton Collected per Station

ORGANISMS Approx. units (individuals (cells)/ L) 50 L = 10 ml – 1 ml	Pulangi 1	Pulangi 2	Pulangi 3	Pulangi 4	Pulangi 5
CYANOPHYCEAE					
Calothrix				*17*	*23*
Lyngbya	-		10	5	13
Oscillatoria	3		6	21	5
Subtotal	**3**	**0**	**16**	**43**	**41**
CHLOROPHYCEAE					
Pediastrum	*1*		*4*		
Scenedesmus		4		12	36

ORGANISMS Approx. units (individuals (cells)/ L) 50 L = 10 ml – 1 ml	Pulangi 1	Pulangi 2	Pulangi 3	Pulangi 4	Pulangi 5
Syrogyra				16	15
Subtotal	**1**	**4**	**4**	**28**	**51**
BACILLARIOPHYCEAE					
Cymbella	1		4	1	9
Gomphonema	1		1	1	2
Gyrosigma	1	1	2		4
Melosira	1	1		3	6
Navicula	1		2	1	2
Nitzchia		1	1	1	3
Synedra			1	1	1
Subtotal	**5**	**3**	**11**	**8**	**27**
ZOOPLANKTON					
Moina				1	1
Subtotal	**0**	**0**	**0**	**1**	**1**

Fourteen (13) genera of phytoplankton and one (1) genus of micro-crustacean were identified and counted in the water samples.

The phytoplankton was represented by seven (7) genera of diatoms, three (3) genera of cyanobacteria, and three (3) genera of green algae.

Of the stations examined, the most number of plankton genera and number was collected in the Pulangi 5 / Pulangi Lake site, followed Pulangi 4, the site downstream of the Pulangi 5. Considerably lesser the plankton diversity are in the other three downstream sites.

Shannon diversity indices for plankton community in the sampling sites are presented below.

Table 2-55: Plankton Diversity

Plankton DIVERSITY INDICIES			
Shannon's method; Log base 10			
Sample	**Index**	**Evenness**	**Genera Richness**
Pulangi 1	0.795	0.941	7
Pulangi 2	0.501	0.832	4
Pulangi 3	0.824	0.863	9
Pulangi 4	0.83	0.769	12
Pulangi 5	0.902	0.81	13

It is understandable for Pulangi 5 to have the highest index as planton, in general, thrives and reproduces better in relatively standing water environments – compared to flowing water systems like river where current presents a big challenge for establishment of small-size organisms. Pulangi 4, though situated in Pulangi River is just downstream to Pulangi 5 / Pulangi Lake, thus it is conceivable that it also receives spill-over plankton from the outflow of the lake waters to the downstream Pulangi River. In Pulangi 3-5, where the current was observed to be faster, have lesser plankton.

Benthic Macro-invertebrates

In all the sites, macro-invertebrates were collected only along the banks.

Table 2-56: Macro-invertebrates Collected per Station

Taxon (individuals/sq m)	Pulangi 1	Pulangi 2	Pulangi 3	Pulangi 4	Pulangi 5
Aquatic insect larva					
Family Trichoptera	1	2	2		
Family Odonata	2	2	1		1
Family Diptera				1	1
Mollusc					
Gyraulus chinensis					1
Tarebia granifera		1	3	4	8
Melanoides tuberculata	1	1		1	1
Thiara scabra	1	1			1
Pomacea canaliculata	1	1	1	1	2
Radix quadrasi					1
Physastra hungerfordiana					2
Crustaceans					
Caridina sp			3		2
total	6	8	10	7	20

Three family level-taxa of aquatic insect larva were collected in Pulangi 1, 2, 3 – sites where there is more vegetation. Caddisfly larva (Family Trichoptera), usually regarded as pollution-sensitive were collected in Pulangi 1, 2, 3 – indicating a better environment for this taxon. The dragonfly nymphs (Family Odonata) (dragonflies) were collected in Pulangi 1, 2, 3, 5. Dragonflies are usually regarded to have a wider range of tolerance – from sensitive to tolerant and thus can usually survive a variety of environment. It is conceivable that they occur also in Pulangi 4, but in numbers too few to have been sampled. The midges larva (Family Diptera) sampled in Pulangi 4 and 5 are usually regarded as pollution-resistant and thrives in waters with high organic contents and low DO. Their presence in the above sites may indicate these conditions.

Most of the macro-invertebrates collected comprised the freshwater gastropods. *Gyraulus, Physatra*, and *Radix,* are usually epiphytic in bank vegetation and could not easily withstand strong current, thus they were collected in Pulangi 5 only. The other four molluskan species can stand strong current, living in the undersides of stones and thriving in eddy portions of the bank. These species however, thrives well also in relatively stagnant waters of Pulangi 5. All of the molluskan taxa collected can thrive in relatively clean to polluted waters.

As to crustaceans, only the small caridean shrimps were collected in our improvised seine nets, and only in Pulangi 3 and 5.

The macro-invertebrate diversity indices are presented in the table below.

Table 2-57: Macr-invertibrate Diversity

MACRO-INVERTEBRATE DIVERSITY INDICIES			
Shannon's method; Log base 10			
SITES	Index	Evenness	Taxon richness
Pulangi 1	0.678	0.97	5
Pulangi 2	0.753	0.967	6

Pulangi 3	0.654	0.935	5
Pulangi 4	0.501	0.832	4
Pulangi 5	0.849	0.849	10

Pulangi 5 / Pulangi Lake has the highest index and also harbors 10 of the 11 macro-invertebrate taxa collected in the sites. All the rest of the sites, have macro-invertebrates taxa that could withstand relatively stronger water current.

Fishes

Difficulties in collecting fish samples was encountered in all the sampling sites. Aside from a few individuals of the mosquito fish, *Poecilia* sp, caught using an improvise seine net. The local guides informed the team that electro-fishing is not allowed and no local fisherman could perform it for the team. In Pulangi 1, 2, and 3, actual fishing with the use of a cast net was done, however, not a single individual was caught. However, a chance encounter, within the three sites, with one fisherman using gill net gave the opportunity to examine the catch which was composed of about 3 individuals of tilapia (*Oreochromis niloticus*) and 2 individuals of the carp (*Cyprinus carpio*). These two species are not native to the Philippines.

In the way to and within a kilometer of Pulangi 4, we encountered a child carrying 3 medium size grass carps, which he said he caught using an improvised fish line.

During the sampling period, the locals told us that they have personal knowledge of the following fishes that are present in the area and frequency of occurrence:

a. Carpa: *Cyprinus carpio ;*common
b. Tilapia: *Oreochromis niloticus*; common
c. Igat *Anguilla* sp ; rare
d. Haluan/dalag: *Ophiocephalus striatus*; common

2.2.3.4 Overall Assessment of the Freshwater Biota

In the Philippines, with its numerous islands containing a multitude of streams and lakes, it is understandable that there is a dearth of published information on the freshwater biota of most rivers – Pulangi River included. This paucity notwithstanding, 2-3 papers have been published in the past few years by Central Mindanao Mindanao University.

Plankton diversity is generally low in flowing water system, except in areas where there is an extensive pool or eddy portion. Thus, the plankton composition in the rivers could be considered as typical of flowing water systems. The diversity of diatoms, taken as relative to the blue-green and green algae, gives the impression of a relatively "moderate pollution" state at least in Pulangi lake – an observation previously observed by Cequina and Amoroso (1998). Pulangi Lake (Site #5) as expected yielded a richer plankton composition – as a standing water environment is generally favorable to plankton growth. The greater presence of plankton in the Site Pulangi 5, though a flowing water site, could be caused spill-over contributions from Pulangi Lake.

Aquatic insects have been used as indicators of disturbances. The adult stage is terrestrial and some taxa are very sensitive to the state of the surrounding vegetation. On the other hand, their larvae are aquatic and the survival of the larvae also depends on the state of the aquatic environment. So far,

the substratum of the rivers generally offers a good substrate for most of the larvae. The presence of pollution sensitive taxa (eg ephemeropterans and trichopterans) in the rivers paints a picture of a state with "little" man-made perturbations in Pulangi 1-3. However, the densities of individuals noted are low. Such may be caused by 1) relatively few adults - that mirrors the state of the terrestrial environment, or 2) high mortality of the larvae - that mirrors an unfavorable state of the waters, or 3) low colonization in general - that mirrors the general ecological history of the watershed or the island itself. The first two reasons are of concern in ecological monitoring and therefore must be explored further. In contrast, Pulangi lake, with its sandy-muddy bottom and its proximity to human habitation is expected to have insects that generally prefer environments with lots of vegetation and generally undisturbed.

Crustacean diversity is relatively low, considering that the sites, in general appear to be good habitats for macro-crustaceans. The limitations of the sampling method employed in collecting macro-crustaceans (murky waters, fast current, time/site constraints, etc).

Molluscan fauna noted is generally typical of freshwater systems in the Philippines. In general, the molluscan diversity is low. Again the physical characteristics of Site 1-4, current, murky waters, etc, could make colonization of mollusks difficult. Cequina and Amoroso (1998) reported 5 invertebrate species in Pulangi Lake – we were able to observed more. Perhaps the species that are reported here were just too few to have been collected then.

Fish fauna is relatively depauperate, and even the local fishermen's catch usually comprised the common carp and tilapia. Seldom are the occasions that they would be able to catch the highly prized eel. Cequina and Amoroso (1998) reported 9 fish species in Pulangi lake – a number that is usually expected in a man-made reservoir, where the species present usually mirrors that of Pulangi river. Within the Mt Musuan area, including tributaries of Pulangi River, twelve(12) species were recently reported (Quimpang et al, 2015). The above report, noted though, that only one(1) – *Puntius binotatus* – is native to the Philippines, all the others are introduced.

2.2.3.5 Impact on the Proposed Project and Possible Mitigation Measures

<u>1. Expansion of existing access road to the Dam area,</u>

Road-works impacts on freshwater systems include: 1. siltation from ground disturbances, 2. oil and other machinery pollution, and 3. human pollution/disturbances.

The degree of impact from the above causes depends on the distance of the road to the water system -the nearer the rehabilitation work - the higher and more likely the impact occurs. Some parts of the road existing road networks are far from the rivers, but others are alongside. Where road expansion is needed, earth moving activities will always resort to soil erosion especially during the rainy season and silt may eventually reach surface water systems – tis occurs also to any site where there would be changes in the soil – soil removal or soil impoundment. Siltation has a profound impact on freshwater biota in that it hinders respiratory efficiency in aquatic organisms (macro-invertebrates and vertebrates, including larval amphibians). Also, if the water is use for personal and domestic use (bathing, washing, etc), silt materials increases turbidity of water making it unsuitable for the above uses.

Mitigation measures include: 1. work be done during the dry season, 2. minimize area of earth moving and efficient collection of excess earth materials, and 3. road-bank soil erosion prevention/minimization (use of biological or non-biological structures).

Heavy equipment need oil and gasoline. Spillage from leaks, equipment washing, etc. may reach the river water and cause pollution. The most effective prevention/mitigation strategy is imposition and implementation of rules on spillage.

Road workers will have excretory needs, of which the presence of a nearby river is usually seen as a convenient blessing. Fecal waste contributes towards biological pollution as well as profoundly reduces the aesthetic condition of rivers. Food-related waste, especially the non-biodegradable ones may also eventually reach the river waters. The effective strategy is prevention by the provision of "portalets" and other appropriate toilet facilities that prevents or minimizes fecal contamination of the soil and subsequently the water system.

Road works impact is usually highest during the construction period. It is expected that once road surfaces, roadside areas and embankments are stabilized, then siltation would be lessened.

2. Construction of the dam.

There are two major impacts of the dam: A. Construction-related impacts and B. hydrological changes.

Construction-related impacts are similar to what has been stated earlier on road-works: 1. siltation from ground disturbances, 2. oil and other machinery pollution, 3. human pollution/disturbances, 4 dam structure related impacts like cement-related chemicals that would be washed in the waterway. As above, the impacts would be highest during construction.

Hydrological changes may be somewhat permanent- as long as the dam exists- and these changes do not occur in isolation, especially as to its impact on the biodiversity of Pulangi River. They are:

a. Transformation of the dam areas (high and low) from a running water environment to a standing water environment.

   Such a change may lead to a drastic change in the taxa composition and structure of the impact area (Reynolds et al 1994). As to primary productivity, a lentic environment would be conducive to the growth of phytoplankton in general. Thus, it is predicted that phytoplankton density would increase. An increase in species richness would depend on the rate of colonization by species not observed now due to depressed densities or due to non-successful establishment. An increase in primary productivity would probably also lead to an increase in secondary productivity. The effect of a lentic environment on aquatic macro-invertebrates may be equivocal. On one hand, the increase depth reduces the favorable substratum for aquatic insect larva to only the banks of the impounded dam waters. The steep banks usually are unstable and do not have the hard surfaces of a stony river bottom. The same shift in composition of molluscs may be expected. The river molluscs are dominated by running water tolerant species like the thiarids and melanid. In the lake environment, though these species could still thrive, molluscs that thrive well in standing waters, like pilids, planorbids and lymnaeids, may increase in number. Shrimps may also increase in number but could be found in the banks. As to fishes, we may expect an general increase in fish number and diversity. As has been observed in Pulangi lake, dams changes the river typology from a running water environment to a standing water environment, and this may be favorable to a lot of fishes especially those that are considered as a valuable fishery resource – eg. the introduced tilapia and carps - but maybe detrimental to the running water species like the benthic gobies and the migratory species like eels.

b. Dams also reduce water flow and would probably release (from erosion) and concentrate pollutants downstream. It is expected that heavy metals and other chemical, otherwise confined in rocks and deep soils, may be release because of earth movement during construction, horizontal erosion of the banks, and dissolution in water. It should be considered that the project may exacerbate the problem, at least during construction. The Water development projects hopefully would lead to an increase in economic productivity. Such however could also lead to a growth in population and an expansion of urban complexes (or transformation of rural to urban communities) and the appearance of associated problems of potable water supply, sanitation, water pollution, and depletion of groundwater aquifers. The Bukidnon LGU should be cognizant of these and should reconcile the needs of province with biodiversity conservation, and resource use sustainability.

2.2.3.6 Proposed Monitoring Scheme of Freshwater Environment during the Construction Phase

1. Sampling sites:
   a. Pulangi Lake
   b. Two (2) sites in Pulangi River between Pulangi lake and the proposed dam
   c. One (1) site from a Pulangi river tributary with headwaters from Mt Musuan.
   d. One (1) site in the Pulangi river in the vicinity of the proposed dam
   e. Two (2) sites in Pulangi river within at least 3 km downstream of the proposed dam and power structures.
2. Sampling regime:

a) physico-chemical parameters: monthly for DENR DAO 2016-08 parameters, including microbiological analyses

b) ecotoxicological analyses : quarterly : for heavy metal content of river water and substrate, as well as fish (preferably those that are eaten by locals)

c) biological system analyses : bi-annual (wet and dry season): fish, macro-invertebrates, and plankton

3. Data analyses: Same as above but incorporate time-series data analyses
4. An ecosystem approach in monitoring should be done. This necessitates the integration of the various data (air, water, land, biota, eco-toxicology, etc). Though each module (eg, freshwater biology) can be done by an area expert, data from the other modules should be made available to each area expert so that a more in-depth analyses and discussion can be made.

2.3 Air

This section presents the existing conditions at the project site in terms of meteorology, air quality, and noise. The identified potential impacts during construction and operation of the proposed project including the corresponding mitigating measures to address the identified potential impacts are also discussed.

2.3.1 Meteorology

In accordance to the Technical Scoping Checklist, the following potential impacts of the project will be assessed:

- Change in local micro-climate (or local climate); and
- Contribution in terms of greenhouse gases (GHG) emissions.

2.3.1.1 Change in Local Climate

2.3.1.1.1 Meteorological Data

Meteorological data from the nearest synoptic station to the project site were gathered to characterize the climate in the area. The station, which is owned and operated by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), is located in Malaybalay, Bukidnon with an elevation of 627 meters above sea level (**Figure 2-51**). The station is approximately 80 kilometers away from the project site.

Two types of data were collected: 1) climatological normals (**Table 2-58**) and 2) climatological extremes (**Table 2-59**). The climatatological normals were averaged data from 1981 to 2000. The 30-year observation period for the climatological normals was based on the definition of the World Meteorological Organization (WMO). This is to account for the climate system of the area that is continually changing due to the interactions between the components, namely: atmosphere, hydrosphere, land surface, and biosphere as well as other external factors, such as volcanic eruptions and human-induced factors. Meanwhile, the climatological extremes data were updated up to end of 2017.

2.3.1.1.2 Normal and Extreme Rainfall

Based on the climate map developed by PAGASA, the proposed project site belongs to a zone classified as Type III (**Figure 2-52**). This type of climate has no pronounced season. This zone is relatively dry from November to April and wet for the rest of the year. As shown in **Table 2-58**, the driest month in the area is February with 106.1 mm of rainfall while the wettest month is July with 323.3 mm of rainfall. Annually, this area experiences 222 rainy days while receiving a total of 2,569.9 mm rainfall.

Meanwhile, the greatest rainfall recorded in one day amounted to 195.9 mm. Based on the Climatological Extremes of PAGASA Malaybalay Station (**Table 2-59**), this occurred on October 8, 1979. Records show that there was no typhoon during that time.

Figure 2-51: Location of PAGASA Synoptic Station in Malaybalay, Bukidnon

Table 2-58: Climatological Normals in Malaybalay, Bukdinon (1981 to 2000)

Month	Rainfall (mm)	No of rainy days	Temperature (°C)						VP (mbs)	Rel. Hum. (%)	MSLP (mbs)	Wind (m/s)		Clouds (Okta)	No. of days With	
			Max	Min	Mean	Dry Bulb	Wet Bulb	Dew Pt.				Dir.	Speed		TSTM	LTNG
Jan	142.5	16	29	17.9	23.4	23	21.2	20.4	23.9	85	1009	S	1	6	1	1
Feb	106.1	13	29.4	17.6	23.5	23.1	21.2	20.4	23.9	84	1010	E	1	6	2	1
Mar	112.5	13	30.6	17.6	24.1	23.9	21.5	20.5	24	81	1005	S	1	5	3	2
Apr	115.6	12	31.7	18.1	24.9	24.6	22	20.9	24.6	80	1009	S	1	5	6	6
May	224.8	10	31.2	19.1	25.1	24.9	22.7	21.8	26.1	83	1006	S	1	6	14	11
Jun	313.5	23	29.8	19.2	24.5	24.1	22.4	21.7	25.9	86	1009	S	1	6	13	9
Jul	323.3	24	29	18.9	24	23.6	22.1	21.5	25.6	88	1009	S	1	7	14	9
Aug	294.4	22	29.1	18.8	23.9	23.5	22	21.4	25.4	88	1009	S	1	7	13	9
Sept	315.7	24	29.5	18.7	24.1	23.6	22.1	21.5	25.6	88	1009	S	1	7	15	10
Oct	314.7	23	29.6	18.9	24.2	23.7	22.2	21.6	25.7	88	1009	S	1	6	15	11
Nov	176.1	18	30	18.6	24.3	23.8	22.1	21.4	25.4	86	1009	S	1	6	7	7
Dec	130.7	16	29.5	18.3	23.9	23.5	21.6	20.8	24.5	85	1009	S	1	6	3	4
Annual	**2569.9**	**222**	**29.9**	**18.5**	**24.2**	**23.8**	**21.9**	**21.1**	**25**	**85**	**1009**	**S**	**1**	**6**	**106**	**80**

(Source: PAGASA)

Notes:

VP – Vapor Pressure
mbs – millibar
MSLP – mean sea level pressure
Dir – direction
TSTM – thunderstorm
LTNG – lightning

Table 2-59: Climatological Extremes in Malaybalay, Bukdinon (as of 2017)

Month	Temperature (°C)				Greatest Daily Rainfall (mm)		Highest Wind (m/s)			Sea Level Pressure			
	High	Date	Low	Date	Amt	Date	Spd	Dir	Date	High	Date	Low	Date
Jan	34.0	01-23-1988	11.7	01-16-1956	140.6	01-14-2014	22	NE	01-07-1974	1020.5	01-28-1949	987.0	01-07-1972
Feb	35.2	02-05-2002	10.0	02-04-1973	109.2	02-07-1962	19	NE	02-10-1974	1019.4	02-19-1949	998.1	02-28-1972
Mar	35.5	03-31-1990	12.0	03-01-1949	170.6	03-19-1982	14	NE	03-01-1992	1019.6	03-26-1949	998.9	03-17-1970
Apr	36.4	04-15-2016	12.5	04-02-1996	184.2	04-06-1999	21	NW	04-05-1966	1019.2	04-27-1949	996.6	04-24-1971
May	36.2	05-16-1998	14.0	05-08-2010	126.3	05-15-1991	18	WNW	05-05-1966	1019.9	05-02-1949	997.9	05-25-1971
Jun	34.5	06-14-2017	13.0	06-26-1962	130.4	06-07-2002	18	N	06-20-1985	1019.6	06-11-1949	999.4	06-14-1974
Jul	33.0	07-15-2001	14.0	07-04-2017	135.4	07-05-2016	15	S	07-28-1992	1015.3	07-22-2015	997.4	07-04-1967
	33.0	07-15-2016	-	-	-	-	-	-	-	-	-	-	-
Aug	33.5	08-07-2000	15.0	08-24-2010	113.6	08-01-1978	22	SW	08-28-1984	1016.2	08-11-1997	998.0	08-23-1967
	-	-	15.0	08-10-2016	-	-	-	-	-	-	-	-	-
Sep	34.0	09-03-2007	15.3	09-21-1986	128.6	09-29-2010	18	NW	09-02-1971	1015.9	09-30-1997	998.6	09-20-1971
Oct	34.0	10-31-1995	14.9	10-30-1968	195.9	10-08-1979	20	N	10-21-1982	1016.3	10-11-1997	960.6	10-12-1970
Nov	34.8	11-29-1968	13.1	11-29-1967	144.8	11-20-1993	19	SW	11-22-1973	1015.9	11-07-1997	996.1	11-20-1973
Dec	33.6	12-08-2002	12.5	12-06-2009	112.4	12-21-2017	14	NE	12-21-1973	1017.4	12-12-2002	998.2	12-24-1954
Annual	**36.2**	**04-24-1998**	**10.0**	**02-04-1973**	**195.9**	**10-08-1979**	**22**	**NE**	**01-07-1974**	**1020.5**	**01-28-1949**	**960.6**	**10-12-1970**
	36.2	**05-16-1998**	**-**	**-**	**-**	**-**	**22**	**SW**	**08-28-1984**	**-**	**-**	**-**	**-**
Period of Record	**1949 - 2017**				**1952 - 2017**		**1966 - 2017**			**1949 - 2017**			

(Source: PAGASA)

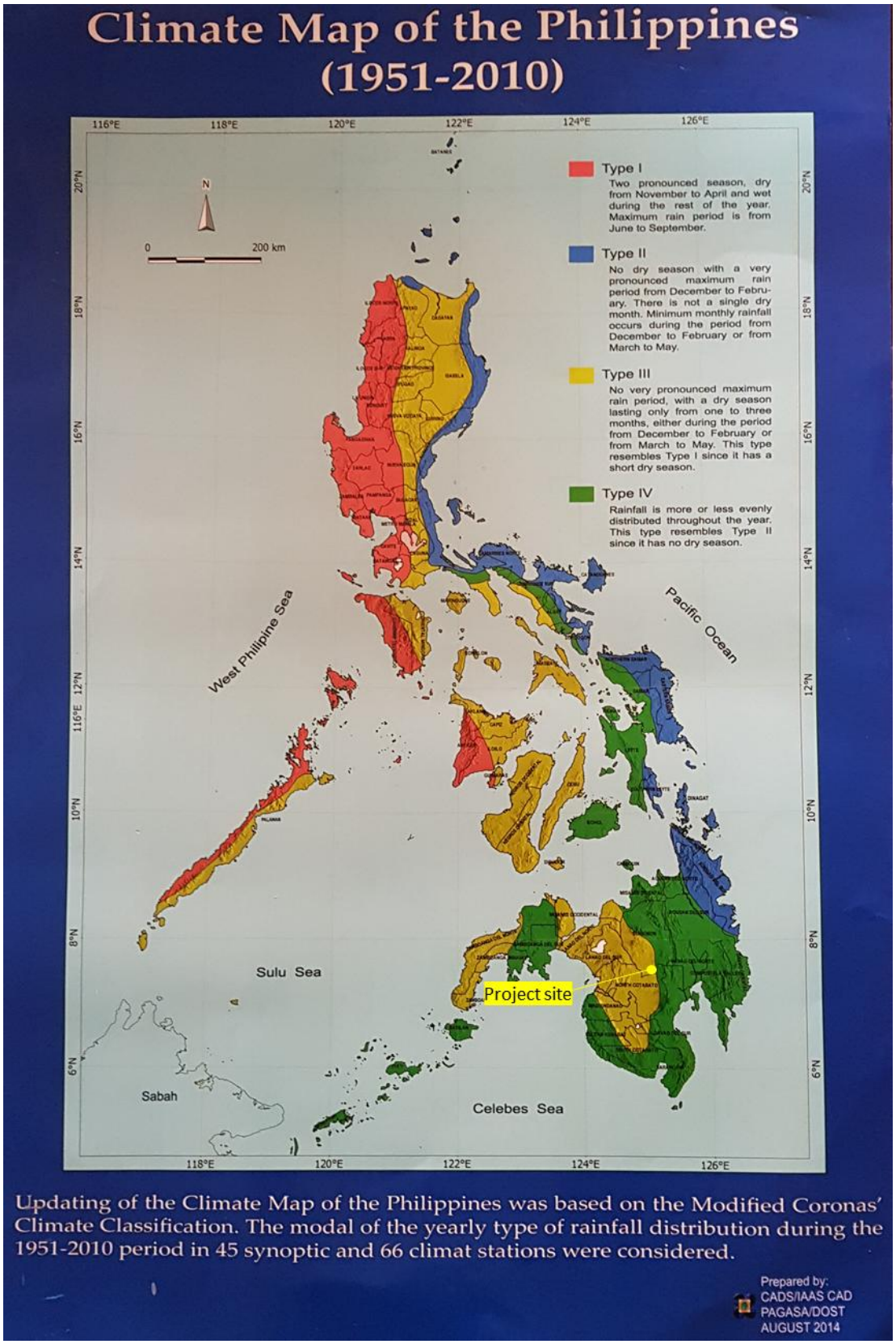


Figure 2-52: Climate Map of the Philippines Indicating the Location of the Project Site (Source: PAGASA)

2.3.1.1.3 Projected Rainfall

Climate projections published by PAGASA in 2011 showed that rainfall in Bukidnon will likely decrease by approximately 8.3% during the period of 2036 to 2065 (centered at 2050). As shown in **Figure 2-53**, annual rainfall during the baseline years (1971 to 2000) amounting to 1,878.6 mm will slightly reduce to 1,824.8 mm by 2006 up to 2035 (centered at 2020). After 2035, the annual rainfall is expected to further decrease to 1,722.3 mm.

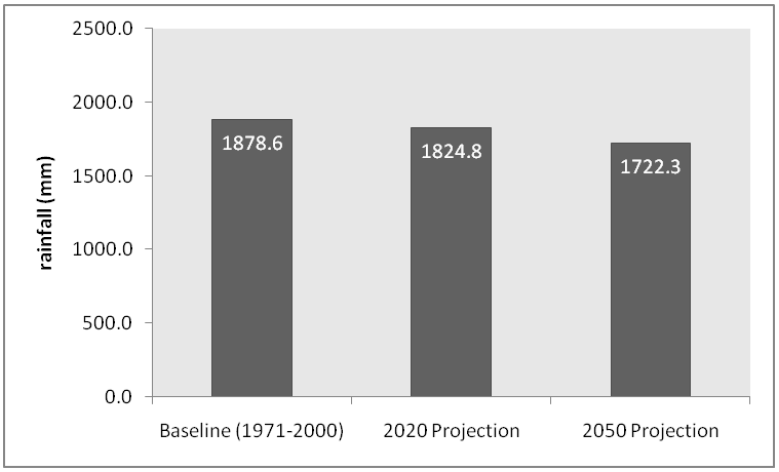


Figure 2-53: Annual Rainfall Projections

Meanwhile, seasonal projections also showed the same decreasing projections in rainfall (**Figure 2-54**). With the exemption of the 2020 projection for the December-January-February period, all projections show that rainfall will slightly decrease all throughout the year.

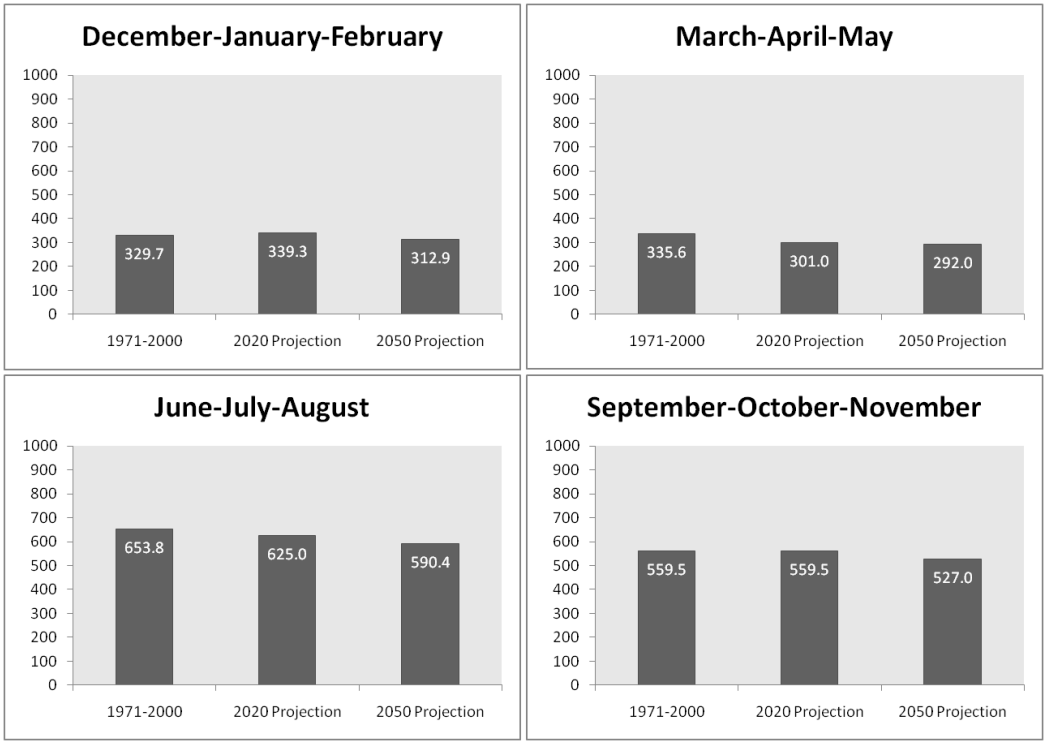


Figure 2-54: Seasonal Rainfall Projections

Figure 2-55 (a) shows that the number of projected dry days will decrease from the baseline period (1971 to 2000) of 6,537 days to 3,977days in 2006 to 2035 (centered at 2020) then will slightly increase again to 4,461 days in 2036 up to 2065 (centered at 2050). Further, during the baseline period, there were no occurrence of rainfall exceeding 300 mm in a single day. Based on the projections of PAGASA (**Figure 2-55 (b)**), greatest daily rainfall exceeding 300 mm will occur at least once in Bukidnon for both 2020 and 2050 projections.

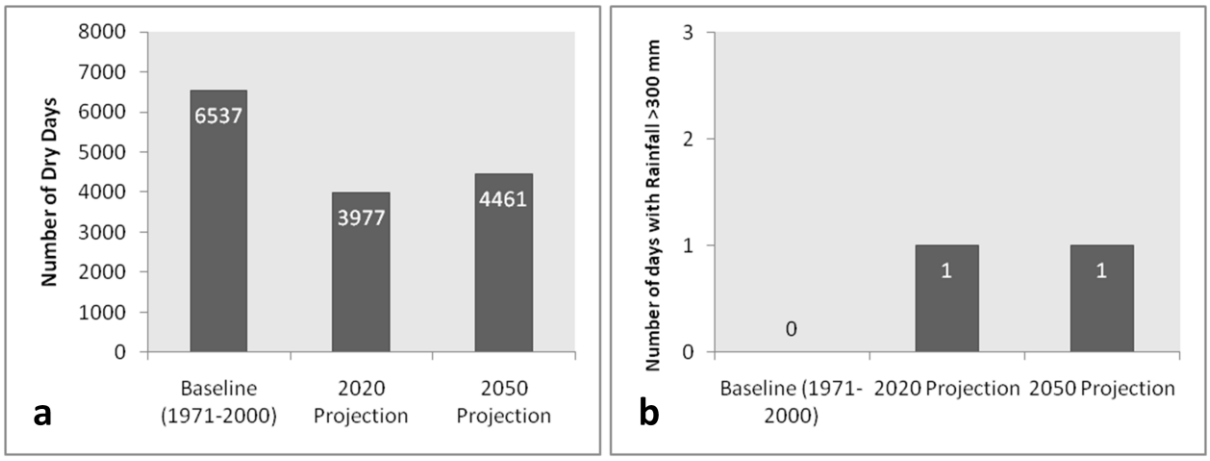


Figure 2-55: a) Projected Number of Dry Days; b) Projected Number of Days wih Rainfall > 300mm

2.3.1.1.4 Ambient Air Temperature

Figure 2-56 shows the ambient air temperatures extracted from the climatological normals. Based on the data, the hottest month in the area is May during the summer season with an average temperature of 25.1°C. The hottest day recorded was on April 24, 1998 and May 16, 1998 with temperatures reaching 36.2°C. Meanwhile, the coldest month is January during Northeast Monsoon with an average temperature of 23.4°C. To date, the coldest day recorded occurred on October 8, 1979 wherein ambient air temperature dropped to 10.0°C.

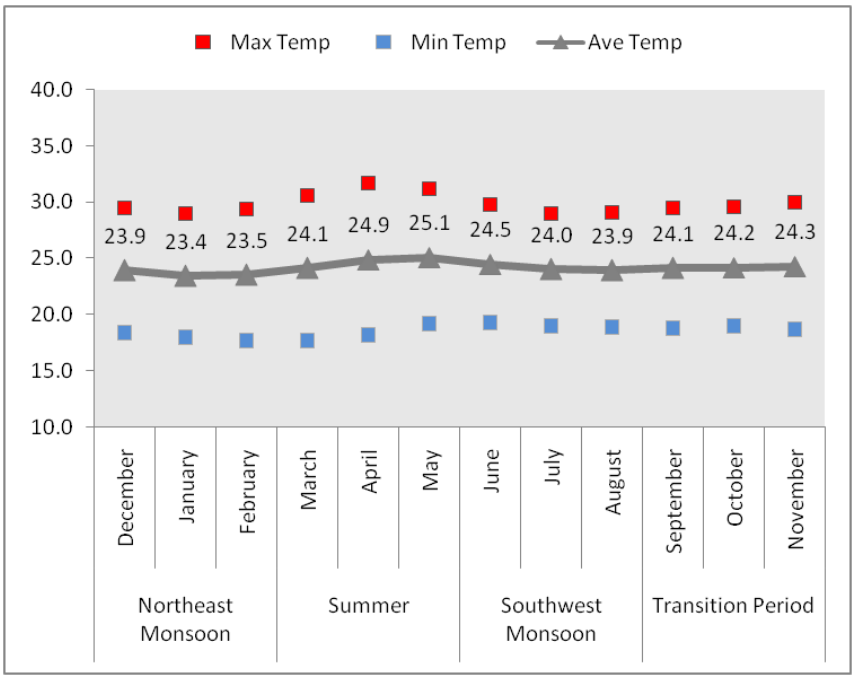


Figure 2-56: Monthly Maximum, Minimum, and Average Ambient Air Temperature

2.3.1.1.5 Projected Ambient Air Temperature

Based on the projection of PAGASA, ambient air temperatures will increase in Bukidnon area by 1 to 1.2°C in 2020 then more than 2°C in 2050 (**Figure 2-57**). During summer season (March-April-May), average ambient air temperatures might increase from a baseline of 26.5°C to 28.8°C. Likewise, the number of days experiencing extreme heat (greater than 35°C) will also increase. From the baseline of 26 days, it will increase to 477 days in 2020 and 441 days in 2050 (**Figure 2-58**).

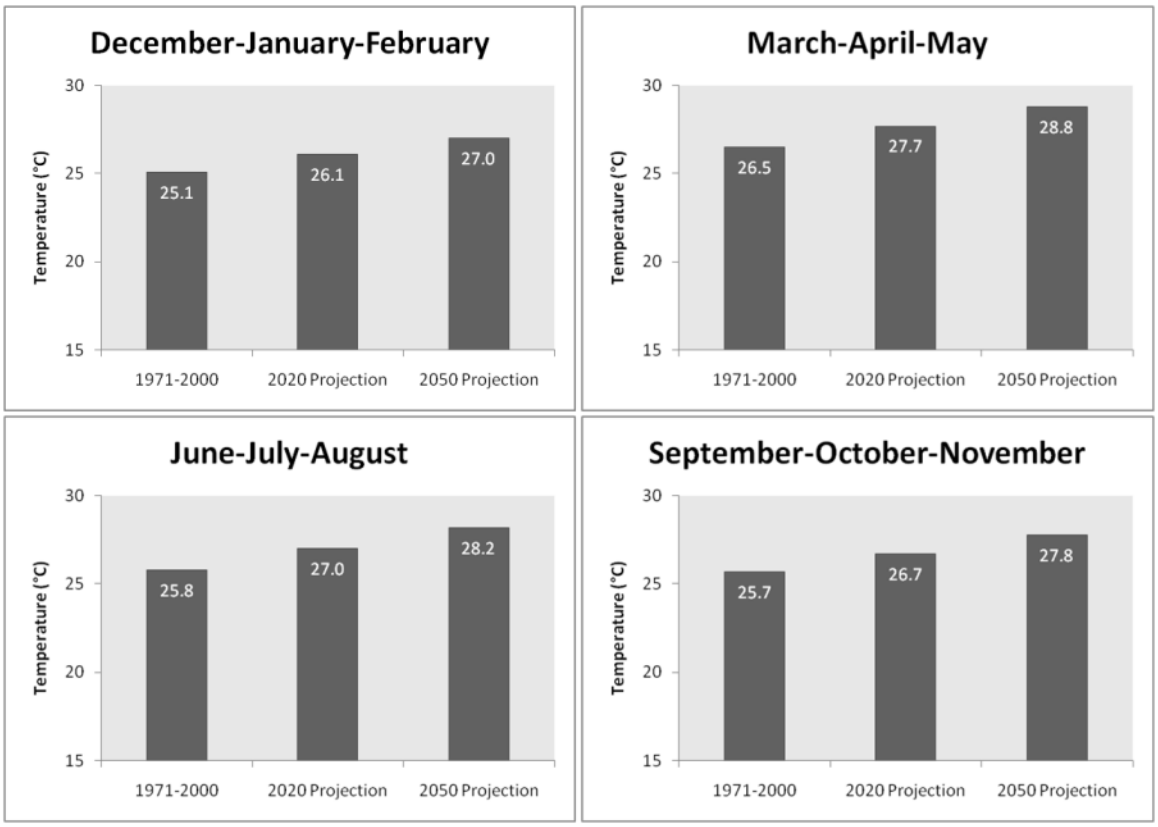


Figure 2-57: Seasonal Temperature Projections

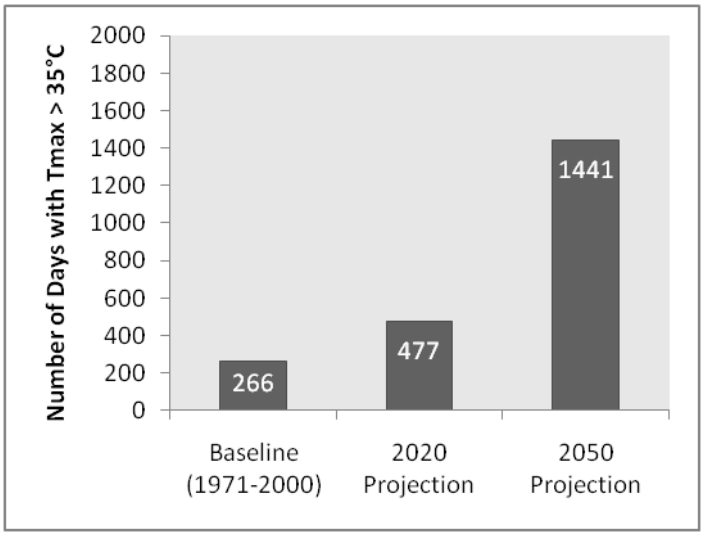


Figure 2-58: Project Number of Days with Extreme Heat

2.3.1.1.6 Prevailing Wind Speeds and Directions

Based on the climatological normals (**Table 2-58**) of the PAGASA Synoptic Station in Malaybalay, Bukidnon, the prevailing wind direction is Southerly. Moreover, the prevailing wind direction is Southerly in 11 out of 12 months. Since the station is located in a complex mountainous terrain with elevation above 600 masl, the prevailing wind directions throughout the year are likely not to follow the same pattern as the monsoons such as Northeast Monsoon from December to February and Southwest Monsoon from June to August. This will be likely scenario at the project site due to the complex surrounding terrain. **Figure 9** presents the view of the project from different directions.

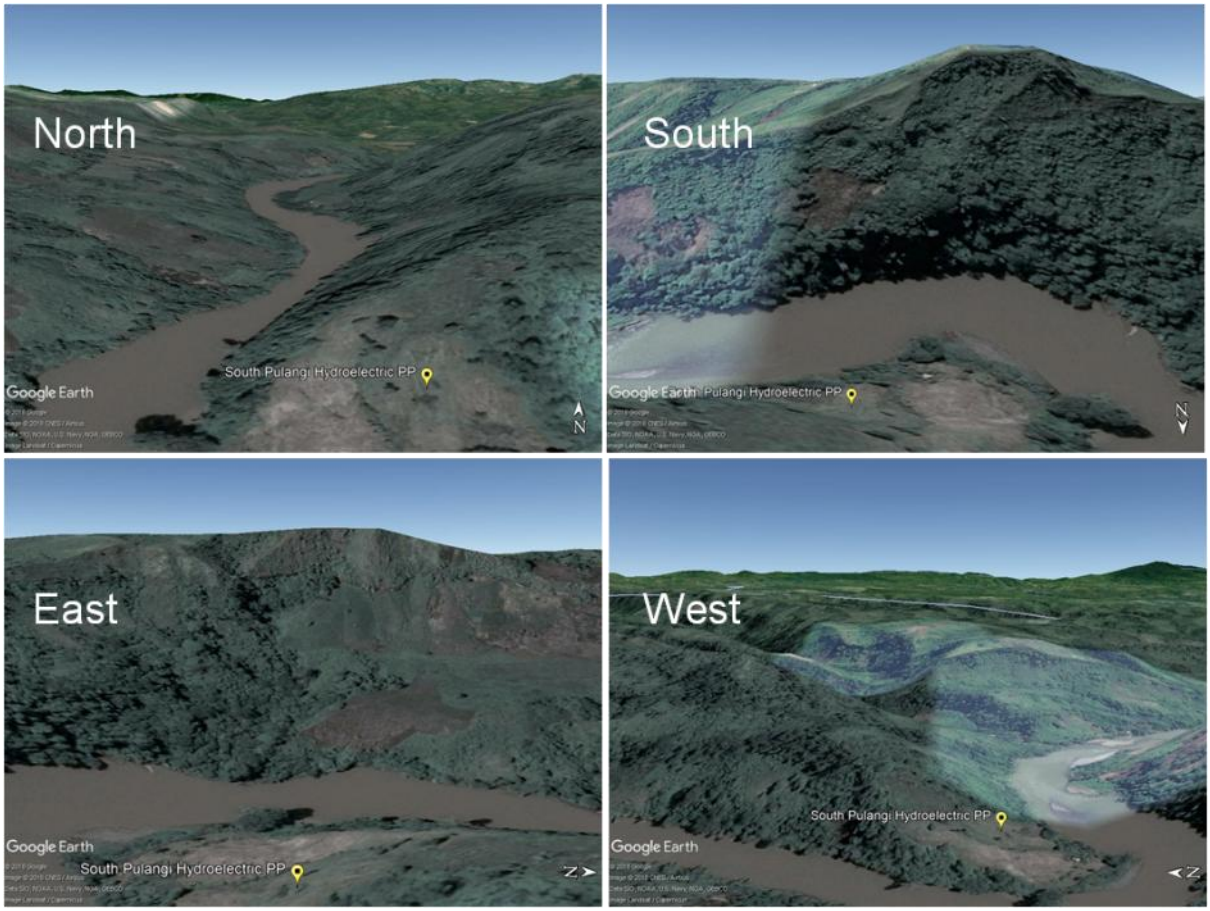


Figure 2-59: Complex Terrain Surrounding the Project Site

2.3.1.1.7 Frequency of Tropical Cyclones and Extreme Wind Speeds

The project site is located in an area where typhoon incidence and risks are very low (**Figure 2-60)**. Based on the database of Unisys (weather.unisys.com), only four tropical cyclones since 1956 came within 100 km of the project site (**Figure 2-61**). These are Typhoon Titang (October 1970), Typhoon Uding (December 1990), Typhoon Pablo (December 2016), and Typhoon Vinta (December 2017). Typhoon Pablo was the strongest tropical cyclone to hit Mindanao. It made landfall as Category 5 super typhoon with winds of 280 kilometers per hour.

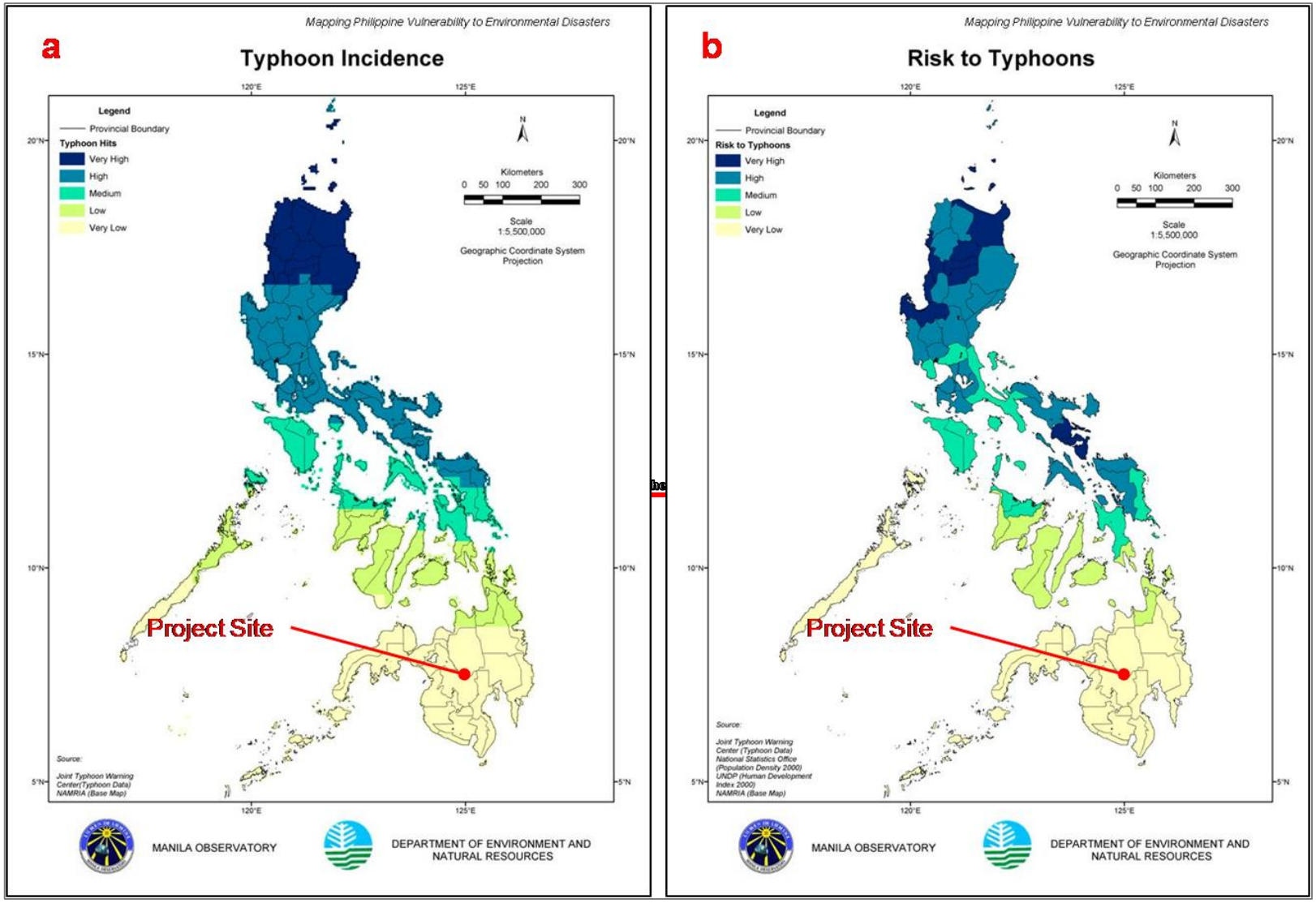


Figure 2-60: Typhoon Incidence and Risk of the Project Site

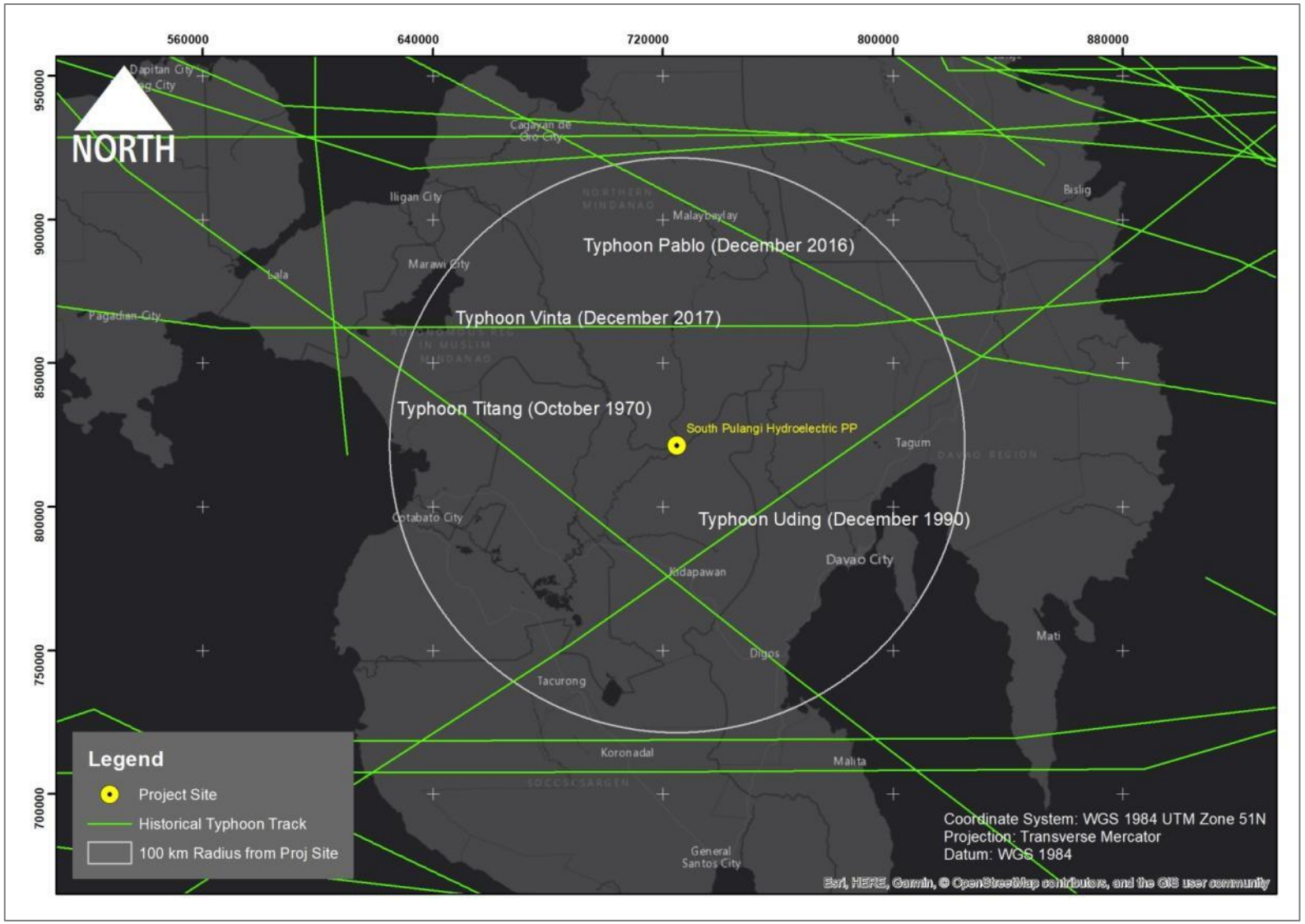


Figure 2-61: Historical Typhoon Tracks within 100 km of the Project Site

2.3.1.1.8 Key Environmental Impacts and Proposed Mitigating Measures

Although the 2020 and 2050 projections showed that there will be a slight decrease in the amount of rainfall received in the area, it was also projected that there will be an increase in extreme weather events for both periods. Such is the case for Typhoon Pablo in December 2016. The design and construction of the facilities should be able to withstand extreme winds and heavy rainfall. The summary of environmental impacts and proposed mitigating measures are summarized in **Table 2-60**.

Table 2-60: Summary of the Significant Impacts and Mitigation Measures Change in Local Climate

Key Environmental Impacts	Phases				Prevention / Mitigation / Enhancement Options
	P	C	O	A	
Projected increase in tropical cyclones in the project site	✓	✓	✓		▪ Design and construction of storm drains (e.g., canals, roof drains) to control water flow during heavy rainfall ▪ Design and construction of the power plant and other buildings and structures to withstand extreme winds and heavy rainfall due to the possible passage of extreme tropical cyclones in the future

2.3.1.2 Contribution in terms of GHG Emissions

2.3.1.2.1 Construction Phase

During construction of the project, temporary increase of GHG is expected due to operation of heavy equipment and back-up generator sets. The construction phase will take four years. GHG emissions of the project are expected to be minimal and temporary. The following are the mitigating measures that can be employed to minimize GHG emissions:

- Reduce idling time of vehicles and heavy equipment;
- Replenish or replant opened space cleared for the construction site as soon as necessary; and
- Regular maintenance of heavy equipment, service vehicles and other motor vehicles to be used during project construction

2.3.1.2.2 Operations Phase

During the operation of the project, GHG emissions are limited only to supporting activities and not from the power generation activity. Primary activities involving GHG emissions are the operation of the black start engines used during start-ups, standby generator sets and fire pumps used during emergency situations, and transportation.

Upon operation, the project will contribute in reducing the carbon emissions of the country due to its negligible carbon emissions as compared to fossil fuels such as coal, oil, and natural gas (**Figure 2-62**).

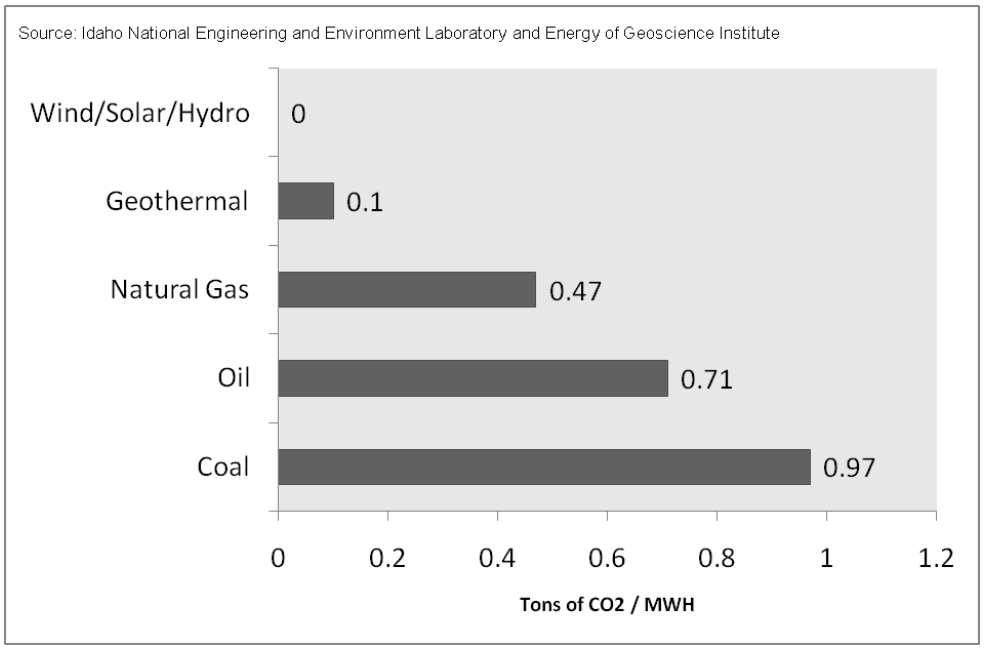


Figure 2-62: Carbon Intensity per Fuel Type

2.3.1.2.3 Key Environmental Impacts and Proposed Mitigating Measures

Table 2-61 summarizes the proposed mitigating measures for the contribution of the proposed project to GHG emissions.

Table 2-61: Summary of the Significant Impacts and Mitigation Measures Contribution in terms of GHG Emissions

Key Environmental Impacts	Phases				Prevention / Mitigation / Enhancement Options
	P	C	O	A	
Contribution in terms of GHG emissions		✓			▪ Reduce idling time of vehicles and heavy equipment ▪ Replenish of replant opened space cleared for the construction site as soon as necessary ▪ Regular maintenance of heavy equipment service vehicles and other motor vehicles to be used during project construction
			✓		▪ Conduct GHG accounting to further reduce direct and indirect emissions

P=Preconstruction, C=Construction, O=Operation, A=Abandonmentt

2.3.2 Air Quality and Noise

In accordance to the Technical Scoping Checklist, the following potential impacts of the project will be assessed:

- Degradation of air quality; and
- Increase in ambient noise level.

2.3.2.1 Degradation of Air Quality

2.3.2.1.1 Sampling Location and Methodology

Ambient air quality baseline sampling was conducted on September 5 to 6, 2018 in potential impact areas of the proposed project (**Figure 2-63**). A total of six stations were monitored for Total Suspended Particulates (TSP), Particulate Matter less than 10 microns (PM_{10}), Sulfur Dioxide (SO_2), and Nitrogen Dioxide (NO_2). The description of each sampling station is presented in **Table 2-62.**

Table 2-62: Description of Sampling Stations and Observations During Sampling

Station	Description and Observation During Sampling	Photodocumentation
A1 – Purok 10, Kikipot, Talahiron, Kibawe, Bukidnon September 5, 2018 0850H-0950H	The station was situated on a cemented ground near an area where coconut shells are dried. Trees and plants are located at a proximate distance to the sampling site. Burning of trash was observed near the sampling area Weather was fair with mostly cloudy skies. Winds were blowing from southwest at light air conditions. No rainfall observed during sampling. Average ambient air temperature was 30.9°C	
A2 – Tumaras, Kibawe, Bukidnon Barangay Hall September 5, 2018 1040H-1140H	The station was situated on a cemented ground near barangay hall. Trees and plants are located a proximate distance to the sampling site. Stacked cable wire rolls and corn drying was observed near the sampling area. Weather was fair with mostly cloudy skies. Winds were blowing from southwest at light air conditions. No rainfall observed during sampling. Average ambient air temperature was 31.6°C	

Station	Description and Observation During Sampling	Photodocumentation
A3 – San Vicente Elementary School September 5, 2018 1350H-1450H	The station was situated on a grassy ground near school's classrooms. Trees and plants are located at a proximate distance to the sampling site. Classes are on-going during the monitoring period. Weather was fair with mostly cloudy skies. Winds were blowing from southwest at light air conditions. No rainfall observed during sampling. Average ambient air temperature was 31.2°C	
A4 – Barangay Kitaihon, Kitaotao September 5, 2018 1530H-1630H	The station was situated on a dusty cemented ground surrounded by trees and plants. Dried plants, scattered rusty galvanized roof and basketball board were observed near the sampling area Weather was fair with mostly cloudy skies. Winds were blowing from southwest at light air conditions. No rainfall observed during sampling. Average ambient air temperature was 34.9°C	
A5 – Mikasili Elementary School (Sitio Mikasili, Brgy. Tangkulan) September 6, 2018 1025H-1125H	The station was situated on a grassy ground remote area near school's classrooms. Trees and plants are located at a proximate distance to the sampling site. Weather was fair with partly cloudy skies. Winds were blowing from southwest at light air conditions. No rainfall observed during sampling. Average ambient air temperature was 31.7°C	

Station	Description and Observation During Sampling	Photodocumentation
A6 – Fatima, Miaray, Dangcagan September 6, 2018 1450H-1550H	The station was situated on unpaved ground with patches of grass by the access road. Trees, plants, and sugarcane farm are located at a proximate distance to the sampling site. Littered dried leaves and sugarcane stalks were observed near the sampling station. Weather was fair with partly cloudy skies. Winds were blowing from southwest at light air conditions. No rainfall observed during sampling. Average ambient air temperature was 32.6°C	

The sampling and analytical procedures were in accordance to the DENR Administrative Order 2000-81 or the Implementing Rules and Regulations of the Philippine Clean Air Act (**Table 2-63**). The following are the description of the procedures:

- **Total Suspended Particulates**. TSP samples were taken using a high volume sampler by drawing air through a glass-fiber filter paper and desiccated for 24-hours after sampling and prior to final weighing. The concentration of TSP in ambient air was calculated by dividing the total weight of particulates collected by the normal volume of air sampled.
- **Particulate Matter less than 10 microns**. PM_{10} samples were taken using a high-volume sampler with a specially-shaped cyclone inlet where larger particulates were separated from PM10 size range. The filter paper with with retained particulates was recovered after sampling and desiccated for 24 hours prior to weighing. The concentration of PM_{10} in ambient air was the weight of the particulates collected divided by the total normal volume of air sampled.
- **Sulfur Dioxide**. SO_2 samples were taken using a handy gas sampler by aspirating air into a solution of sodium tetrachloromercurate (TCM) through an impinger. Samples were then brought to a DENR accredited laboratory for analysis. SO_2 concentration was determined by the difference between the absorbance of the sample and blank multiplied by the calibration factor and divided by the total volume of air sampled corrected to normal temperature and pressure.
- **Nitrogen Dioxide**. NO_2 samples were taken using a handy gas sampler by aspirating air into an azo dye forming reagent. The difference between the absorbance of the sample and the blank multiplied by the calibration factor over the total volume of air sampled gave the concentration of NO_2 in ambient air.

Table 2-63: Methods of Air Sampling and Analysis

Parameter	Sampling/Analytical Method
Total Suspended Particulates (TSP)	High Volume – Gravimetric Method
Particulate Matter < 10 microns (PM_{10})	High Volume- Gravimetric Method
Sulfur Dioxide (SO_2)	Bubbler - Pararosaniline Method
Nitrogen Dioxide(NO_2)	Bubbler - Griesz Saltzman Method

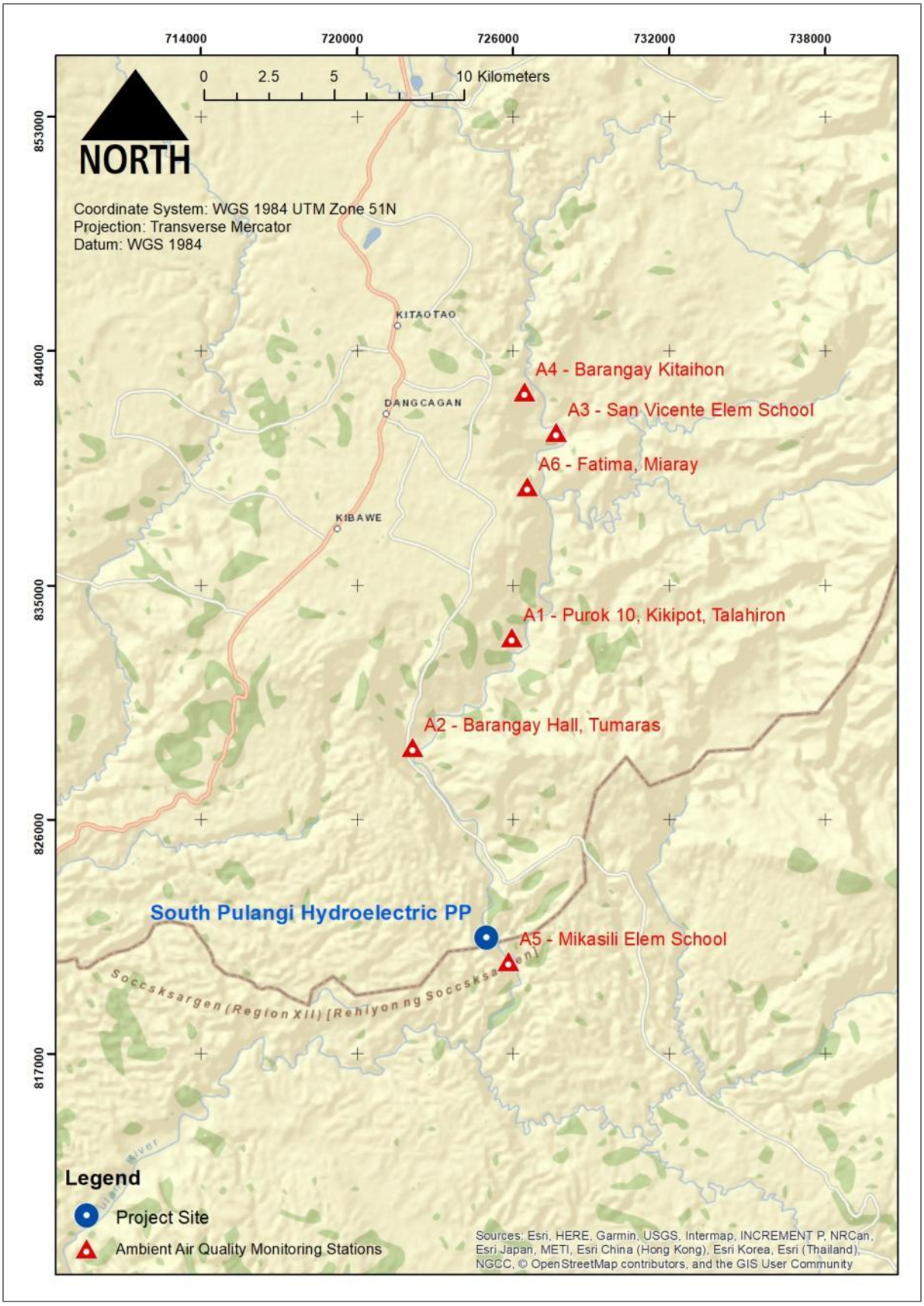


Figure 2-63: Location of Ambient Air Quality Monitoring Stations

2.3.2.1.2 Sampling Results

Table 2-64 presents the results of the baseline sampling at the ambient air quality stations. Resulting pollutant concentrations across all stations complied with the DENR National Ambient Air Quality Standards for Source Specific Air Pollutants.

Table 2-64: Ambient Air Quality Sampling Results (µg/Ncm)

Station ID	Station Name	TSP	PM_{10}	SO_2	NO_2
A1	Purok 10, Kikipot, Talahiron, Kibawe, Bukidnon	191.8	66.5	9.8	1.3
A2	Tumaras, Kibawe, Bukidnon Barangay Hall	71.7	32.6	16.3	3.4
A3	San Vicente Elementary School	59.0	55.1	67.8	<0.5
A4	Barangay Kitaihon, Kitaotao	63.1	36.2	14.2	<0.5
A5	Mikasili Elementary School (Sitio Mikasili, Brgy. Tangkulan)	71.9	57.5	9.4	1.3
A6	Fatima, Miaray, Dangcagan	47.2	45.9	17.7	0.6
DENR National Ambient Air Quality Standards for Source Specific Air Pollutants (60-min averaging time)		300	200	340	260

2.3.2.1.3 Key Environmental Impacts and Proposed Mitigating Measures

Fugitive emissions at the project area are expected due to the construction activities. These activities include land clearing, loading and unloading of excavated materials, scraping, and movement of heavy equipment and trucks at the project site and at the access roads.

Although the nearest household or residence is more than 1 km from the proposed project site, measures to control fugitive emissions should be implemented to lessen emissions in the project vicinities. **Table 2-65** presents the proposed mitigating measures.

Table 2-65: Summary of the Significant Impacts and Mitigation Measures for Degradation of Air Quality

Key Environmental Impacts	Phases				Prevention / Mitigation / Enhancement Options
	P	C	O	A	
Increase of suspended particulates in ambient air		✓			▪ Provision of appropriate covers for haul trucks hauling debris, excavated materials and other materials that likely generate fugitive emissions ▪ Frequent watering of unpaved access roads during dry season ▪ Provision of wash down area to remove mud at the tire trucks and heavy equipment ▪ Impose speed limits along access road and at the project site, ▪ Regular road sweeping of accumulated materials (e.g., mud) on paved roads, and ▪ Regular maintenance of heavy equipment and construction equipment.

2.3.3 Increase in Ambient Noise Level

2.3.3.1 Sampling Location and Methodology

Baseline daytime noise sampling was conducted on September 5 to 6, 2018 in potential impact areas of the proposed project (Figure 2-64). Based on the classification of areas specified in the National Pollution Control Commission (now known as DENR) Memorandum Circular No. 002 Series of 1980, N3 (San Vicente Elementary School) and N5 (Mikasili Elementary School) are classified as Class AA. The Class AA is defined as a section or contiguous area which requires quietness, such as an area within 100 meters from school sites, hospitals, and special home for the aged. Meanwhile, the rest of the stations are classified as Class A or section or contiguous area primarily used for residential purposes.

A direct-reading sound level meter was used to collect noise level at each sampling station. A-weighted (dBA) scale was selected as required by the NPCC regulations. A-weighting network most closely approximates the response of the human ear to various sound frequencies. The method sampling was based on Wilson (1989) wherein at least 50 readings were recorded in order to increase the confidence limits of the data.

Sampling was conducted during daytime, between 9:00 AM to 6:00 PM. In accordance to the NPCC regulations, the arithmetic mean of the seven maximum recorded noise levels is regarded as the noise level comparable to the standard.

2.3.3.2 Sampling Results

Table 2-66 presents the results of the baseline sampling at the noise monitoring stations. Results show that only stations N4, N5, and N6 complied with the noise level standards. Stations N1, N2, and N3 exceeded the standards. The primary sources of noise from these areas were animal sounds, vehicular, and anthropogenic activities.

Table 2-66: Daytime Noise Level Sampling Results (dBA)

Station ID	Station Name	Noise Level	Standards	Sources of Noise
N1	Purok 10, Kikipot, Talahiron, Kibawe, Bukidnon	57	55^{A}	Barking dogs and idling truck
N2	Tumaras, Kibawe, Bukidnon Barangay Hall	58	55^{A}	Crowing roosters and barking dogs
N3	San Vicente Elementary School	56	50^{AA}	Playing karaoke machine
N4	Barangay Kitaihon, Kitaotao	50	55^{A}	Passing motorcycle
N5	Mikasili Elementary School (Sitio Mikasili, Brgy. Tangkulan)	42	50^{AA}	Playing children
N6	Fatima, Miaray, Dangcagan	42	55^{A}	Chirping birds

Note:
A – Class A
AA – Class AA

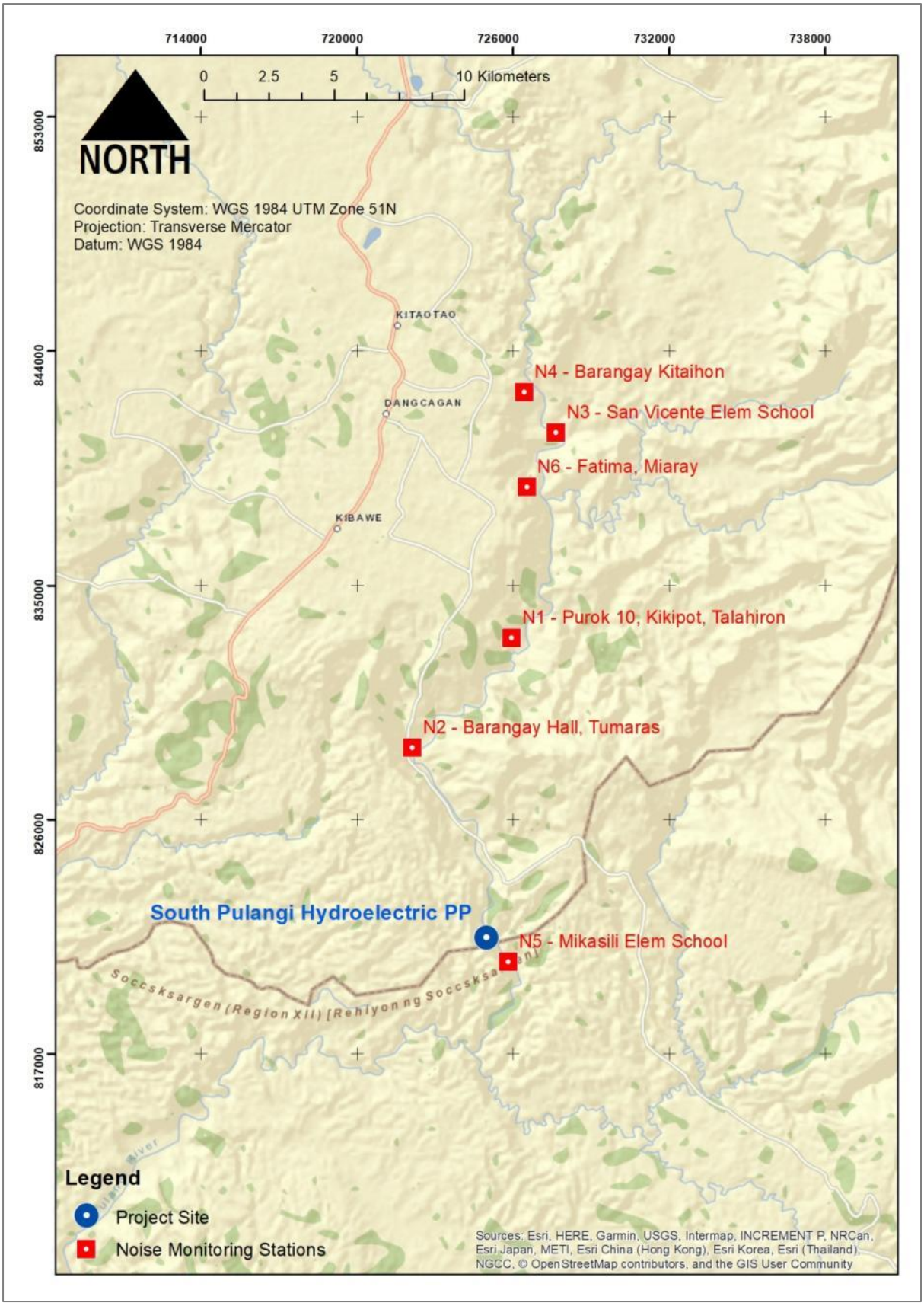


Figure 2-64: Location of Noise Level Monitoring Stations

2.3.3.3 Key Environmental Impacts and Proposed Mitigating Measures

Noise levels during construction period near the project site and access roads is expected to increase due to the influx of noise generating equipment such as backhoes, dump trucks, front end loaders, and generators. Typical noise levels at 15m of this equipment are:

- Backhoe – 80 dBA
- Front end loader – 82 dBA
- Dump truck – 84 dBA
- Generator – 82 dBA

Although the above noise levels are higher when compared to noise standards at residential areas, the attenuated noise at the nearest household area, which is about 1.3 km from the proposed project site, is expected lower due to attenuation of noise with distance and foliage. Thus, there is no significant impact of the proposed project site to noise sensitive receptors our households in terms of noise emission during construction period. Table 2-67 presents the proposed mitigating measures for the increase in noise levels.

Table 2-67: Summary of the Significant Impacts and Mitigation Measures for Increase in Ambient Noise Level

Key Environmental Impacts	Phases				Prevention / Mitigation / Enhancement Options
	P	C	O	A	
Increase in ambient noise levels		✓			▪ Impose speed limits at access roads and within the construction site ▪ Require all heavy equipment and other equipment using internal combustion engines (e.g., generator sets) to install effective mufflers. Significant noise is emitted due to intake and exhaust of the internal combustion engine, which could be effectively reduce using mufflers ▪ Regulate or reduce use of equipment at nighttime, especially those that emits high noise levels ▪ Use of mufflers on heavy equipment and enclosed stationary equipment, such as air compressors and generators
			✓		▪ Design and construction of the power plant which employs noise reducing engineering controls such as dampening, tuned resonance sound absorption, and acoustic barriers

2.4 People

2.4.1 Methodology

This section covers the People Module for the South Pulangi Hydroelectric Power Project of Pulangi Hydropower Corporation. The Project covers the Municipalities of Damulog, Dangcagan, Kibawe and Kitaotao all in the Province of Bukidnon. The assessment was based on the People Module of the Technical Scoping Checklist agreed upon by the Environmental Management Bureau (EMB), the EIA Review Committee and the Proponent which is based on the guidelines set by PD 1586 Philippine Environmental Impact Statement System, DENR DAO 30-2003 (Revised Procedural Manual), DENR MC 005-14 (Revised Guidelines for Coverage Screening and Standardized Requirement) and DENR DAO 2017-15 (Guidelines on Public Participation Under the Philippine Environmental Impact Statement (EIS) System).

The project is located in the Municipalities of Damulog (1 barangay), Kibawe (20 barangays), Dangcagan (3 barangays) and Kitaotao (6 barangays). **Table 2-68** below shows the covered barangays and the associated project components in each barangay and municipality.

Table 2-68: Covered Barangays, Municipalities and Project Components.

Municipality	Barangay	Project Component
Damulog	Tangkulan	Dam Site and Power House
Kibawe	Balintawak	Reservoir Area
	Bukang Liwayway	
	Cagawasan	
	Magsaysay	
	Mascarinas	
	Natulongan	
	Pinamula	
	Sanipon	
	Talahiron	
	Tumaras	
Dangcagan	Dolorosa	
	Miaray	
	San Vicente	
Kitaotao	Balocbocan	
	Kitaihon	
	Kitobo	
	Metebagao	
	San Lorenzo	
	Tandong	

Primary and secondary information were gathered to determine baseline conditions of the affected communities. Secondary information was secured from the following sources:

- Comprehensive Land Use Plan
- Municipal Profile
- Municipal Health Office
- Provincial Physical Framework and Development Plan
- Philippine Statistics Authority
- Department of Education
- Department of Health

Primary information was secured through perception surveys, focused group discussions and IEC activities. The perception survey was conducted using a standard 7-page questionnaire (**Annex 11**). Questions included demographic data, household characteristics, employment and livelihood, available sources of water, waste management and perceived negative and positive effects of the project. The enumerators were oriented and trained in the use of the survey questionnaire. Sample size was computed using Slovin's Formula:

$$n \geq \frac{N}{1 + Ne^2}$$

where,

n=sample size
N=total population
e=error tolerance

What margin of error can you accept? 5% is a common choice	5 %
What confidence level do you need? Typical choices are 90%, 95%, or 99%	95 %
What is the population size? If you don't know, use 20000	5950
What is the response distribution? Leave this as 50%	50 %
Your recommended sample size is	361

With an estimated total number of households of 5,950 and margin of error or 5%, the computed sample size is 361 respondents and was distributed among the four municipalities based on population.

IEC activities and FGDs were also conducted to solicit primary information on the community's perception of the project and to provide a venue for the community members to raise issues and concerns to be addressed by the EIA study and to provide suggestions and recommendations for the Project. It also served as a venue for the possibly affected communities to express their perceived effects of the projects to their respective communities.

With the established baseline conditions, key socioeconomic impacts were identified, based on the following:

- Displacement of Settlers
- In-Migration
- Change in Lifestyle of Indigenous People
- Threat to Public Health
- Generation of Local Benefits from the Project
- Threat to Delivery of Basic Services
- Traffic Congestion

Once the impacts were identified, mitigating and enhancement measures were formulated and consulted to ensure appropriateness and effectiveness of the identified measures. These measures were included in the Social Development Plan (SDP) and the Information, Education and Communication (IEC) Plan Framework included as Section 5 of this report.

2.4.2 Summary of Demographic Data

Table 2-69 shows the population and population growth rate in the project area. Barangay Miaray in the Municipality of Dangcagan has the highest population among the barangays in the project area followed by the Barangays Talahiron (Kibawe) and Natulongan (Kibawe). On the other hand, Barangays Mascarinas (Kibawe), Tumaras (Kibawe), and Metebagao (Kitaotao) registered the lowest population among the affected barangays based on the 2015 Census of Population.

In terms of population growth, Barangay Sanipon (Kibawe) registered the highest population growth among the impact barangays with its population growing by 28.22% between 2010 and 2015. This is followed by Barangays Pinamula (Kibawe) and Mascarinas (Kibawe) which grew by 19.07% and 16.86%, respectively. All three barangays registered a higher increase in population than the municipal level which grew by 9.71% between 2010 and 2015. On the other hand, Barangay Cagawasan (Kibawe) registered the lowest increase in population among the affected barangays growing only by 0.87% between 2010 and 2015. This is followed by Barangays Talahiron (Kibawe) and Balintawak (Kibawe). The increase in population of the three barangays is lower than the municipal average. Barangays Bukang Liwayway (Kibawe), Kitaihon (Kitaotao), Metebagao (Kitaotao), and Tandong (Kitaotao) all experienced a decrease in population between 2010 and 2015.

In terms of population growth rate, Barangay Sanipon (Kibawe) registered the highest average annual growth rate at 5.44% annually between 2010-2015 which is higher than the municipality's average annual population growth rate of only 1.96% between 2010 and 2015. Barangay Cagawsan (Kibawe) also registered the lowest annual average population growth rate at 0.17% annually between 2010 and 2015. Barangays Bukang Liwayway (Kibawe), Kitaihon (Kitaotao), Metebagao (Kitaotao), and Tandong (Kitaotao) all experienced negative annual average growth rate as a result of the decrease their population for the period.

Table 2-69: Population and Population Growth Rate in the Project Area

Barangay/ Municipality	2010 Population	2015 Population	Increase/ Decrease	Average Annual Growth Rate	Estimated 2018 Population
Damulog	**25,538**	**30,302**	**15.72%**	**3.31**	**32,340**
Tangkulan	2,040	2,406	15.21%	3.19	2,562
Kibawe	**35,767**	**39,612**	**9.71%**	**1.96**	**41,182**
Balintawak	735	806	8.81%	1.77	835
Bukang Liwayway	1,037	960	-8.02%	-1.46	932
Cagawasan	911	919	0.87%	0.17	922
Magsaysay	1,541	1,731	10.98%	2.24	1,809
Mascarinas	567	682	16.86%	3.58	732
Natulongan	2,716	3,211	15.42%	3.24	3,422
Pinamula	1,133	1,400	19.07%	4.11	1,517
Sanipon	669	932	28.22%	5.44	1,036
Talahiron	2,929	3,092	5.27%	1.04	3,156
Tumaras	670	767	12.65%	2.61	808
Dangcagan	**22,448**	**23,723**	5.37%	**1.06**	**24,227**
Dolorosa	1,015	1,134	10.49%	2.13	1,183
Miaray	3,268	3,607	9.40%	1.90	3,745
San Vicente	791	897	11.82%	2.42	941
Kitaotao	**49,488**	**50,260**	1.54%	**0.30**	**50,557**
Balocbocan	1,592	1,717	7.28%	1.45	1,767
Kitaihon	550	544	-1.10%	-0.21	542
Kitobo	2,371	2,601	8.84%	1.78	2,694
Metebagao	788	747	-5.49%	-1.01	732
San Lorenzo	681	789	13.69%	2.84	834

Barangay/ Municipality	2010 Population	2015 Population	Increase/ Decrease	Average Annual Growth Rate	Estimated 2018 Population
Tandong	864	806	-7.20%	-1.31	785

Source: Philippine Statistics Authority, 2015 Census of Population and Households, Comprehensive Land Use Plan, Municipal Ecological Profile.

Table 2-70 shows the gross population density by barangay. With a population of 3,422 and land area of 1,580.38 ha, Barangay Natulongan (Kibawe) has the highest population density among the barangays in the project area at 2.17 person/ha this is higher than the population density at the municipal level at 1.04 person/ha. On the other hand, Barangay San Lorenzo (Kitaotao) registered the lowest population density at 0.49 person/ha which is slightly lower than the population density at the municipal level at 0.55. Estimated household size by barangay is shown in **Table 2-71** below.

Table 2-70: Population Density

Barangay/ Municipality	Estimated 2018 Population	Land Area	Gross Population Density
Damulog	**32,340**	**24,566.00**	**1.32**
Tangkulan	2,562	3,803.71	0.67
Kibawe	**41,182**	**39,692.00**	**1.04**
Balintawak	835	406.98	2.05
Bukang Liwayway	932	517.94	1.80
Cagawasan	922	882.48	1.04
Magsaysay	1,809	1,352.73	1.34
Mascarinas	732	1,003.00	0.73
Natulongan	3,422	1,580.38	2.17
Pinamula	1,517	1,022.43	1.48
Sanipon	1,036	1,185.99	0.87
Talahiron	3,156	1,667.61	1.89
Tumaras	808	407.49	1.98
Dangcagan	**24,227**	**42,269.00**	**0.57**
Dolorosa	1,183	1,823.63	0.65
Miaray	3,745	3,665.09	1.02
San Vicente	941	895.39	1.05
Kitaotao	**50,557**	**92,730.00**	**0.55**
Balocbocan	1,767	1,288.00	1.37
Kitaihon	542	621.00	0.87
Kitobo	2,694	1,793.00	1.50
Metebagao	732	887.00	0.83
San Lorenzo	834	1,688.00	0.49
Tandong	785	388.00	2.02

Source: Philippine Statistics Authority, 2015 Census of Population and Households, Comprehensive Land Use Plan, Municipal Ecological Profile.

Table 2-71: Household Size

Barangay/ Municipality	2015 Population	Households	Household Size
Damulog	**30,302**	**6,145**	**4.93**
Tangkulan	2,406	607	3.96
Kibawe	**39,612**	**8,791**	**4.51**
Balintawak	806	185	4.36
Bukang Liwayway	960	157	6.11
Cagawasan	919	167	5.50
Magsaysay	1,731	508	3.41

Barangay/ Municipality	2015 Population	Households	Household Size
Mascarinas	682	529	1.29
Natulongan	3,211	838	3.83
Pinamula	1,400	331	4.23
Sanipon	932	517	1.80
Talahiron	3,092	693	4.46
Tumaras	767	269	2.85
Dangcagan	**23,723**	**5,169**	**4.59**
Dolorosa	1,134	238	4.76
Miaray	3,607	811	4.45
San Vicente	897	190	4.73
Kitaotao	**50,260**	**8,977**	**5.60**
Balocbocan	1,717	359	4.78
Kitaihon	544	110	4.95
Kitobo	2,601	465	5.59
Metebagao	747	128	5.82
San Lorenzo	789	131	6.04
Tandong	806	153	5.27

Source: Philippine Statistics Authority, 2015 Census of Population and Households, Comprehensive Land Use Plan, Municipal Ecological Profile.

2.4.3 Access to Basic Services

2.4.3.1 Education

Table 2-72 and **Table 2-73** show the elementary enrolment and secondary enrolment in the project area. In general, there are more male than female enrolled across all municipalities at the elementary level and while the opposite is true at secondary levels. Only Barangays Mascarinas ES (Kibawe), Dolorosa ES (Dangcagan), and Metebagao ES (Kitaotao) registered a higher number of females enrolled at the elementary level. At the secondary level, in general, there are more female secondary school students than males. This is the same scenario in the Municipalities of Damulog, Dangcagan and Kitaotao while in the Municipality of Kibawe, there is an almost equal number of male and female students at the secondary level.

Table 2-72: Elementary School Enrolment

School	Elementary School Enrolment				
	Male	%	Female	%	Total
Damulog					
Tangkulan ES	208	50.36%	205	49.64%	413
Kibawe					
Balintawak ES	99	51.56%	93	48.44%	192
Bukang Liwayway ES	143	55.00%	117	45.00%	260
Cagawasan ES	111	52.36%	101	47.64%	212
Magsaysay ES	67	55.37%	54	44.63%	121
Mascarinas ES	69	47.59%	76	52.41%	145
Natulongan ES	380	51.56%	357	48.44%	737
Pinamula ES	186	55.03%	152	44.97%	338
Sanipon ES	133	51.95%	123	48.05%	256
Talahiron ES	192	52.32%	175	47.68%	367
Tumaras ES	73	50.69%	71	49.31%	144
Dangcagan					
Dolorosa ES	139	48.77%	146	51.23%	285
Miaray ES	361	52.78%	323	47.22%	684
San Vicente ES	90	52.33%	82	47.67%	172

School	Elementary School Enrolment				
	Male	%	Female	%	Total
Kitaotao					
Balocbocan ES	186	51.81%	173	48.19%	359
Kitubo ES	294	53.16%	259	46.84%	553
Metebagao ES	72	49.66%	73	50.34%	145
San Lorenzo ES	89	52.35%	81	47.65%	170
Tandong ES	108	56.25%	84	43.75%	192
Total	**3,000**	**52.22%**	**2,745**	**47.78%**	**5,745**

Table 2-73: Secondary School Enrolment

School	Secondary School Enrolment					
	Municipality	Male	%	Female	%	Total
Kibawe NHS	Kibawe	453	50.00%	453	50.00%	906
Macapari NHS	Damulog	115	46.00%	135	54.00%	250
Old Damulog NHS	Damulog	625	50.48%	613	49.52%	1,238
Dangcagan NHS	Dangcagan	493	47.59%	543	52.41%	1,036
Dangcagan NHS - Miaray Annex	Dangcagan	152	45.24%	184	54.76%	336
Kitubo NHS	Kitaotao	259	45.68%	308	54.32%	567
Kitaotao NHS - Digongan Annex	Kitaotao	69	60.00%	46	40.00%	115
Kitaotao NHS	Kitaotao	551	49.68%	558	50.32%	1,109
Sinuda NHS	Kitaotao	271	45.24%	328	54.76%	599
South Dalurong Integrated School	Kitaotao	45	45.00%	55	55.00%	100
White Kulaman Integrated School	Kitaotao	56	57.14%	42	42.86%	98
TOTAL		**3,089**	**48.62%**	**3,265**	**51.38%**	**6,354**

2.4.3.2 Sanitation and Water Supply

Table 2-74 shows the type of toilet facilities available by municipality. Records show that, overall, around 47% have access to sanitary toilets, 35% utilizes unsanitary toilet facilities while around 18% have no toilet facility at all. In Barangay Tangkulan in Damulog, 30% has sanitary toilet, 35% has unsanitary toilet while around 35% has no toilet. In the Municipality of Kibawe, most of the residents in Barangays Balintawak, Mascarinas, Natulongan, Talhiron and Tumaras have access to sanitary toilet. Most of the households in Barangays Magsaysay, Vagawasan, and Pinamula have access to unsanitary toilets. In Barangay Sanipon, 44% of the households have no toilet facilities. In the Municipality of Dangcagan, most of the residents of Barangays Miaray and San Vicente have access to sanitary toilets while majority of the residents of Barangay Dolorosa utilizes unsanitary toilets.

Table 2-74: Type of Toilet Facility

Barangay/ Municipality	Type of Toilet Facilities					
	Sanitary Toilet	%	Unsanitary Toilet	%	Without Toilet	%
Damulog						
Tangkulan	148	30.83%	166	34.58%	166	34.58%
Kibawe						
Balintawak	88	45.83%	78	40.63%	26	13.54%
Bukang Liwayway	79	36.07%	83	37.90%	57	26.03%
Cagawasan	71	34.13%	84	40.38%	53	25.48%

Barangay/ Municipality	Type of Toilet Facilities					
	Sanitary Toilet	%	Unsanitary Toilet	%	Without Toilet	%
Magsaysay	85	19.95%	251	58.92%	90	21.13%
Mascarinas	77	52.38%	44	29.93%	26	17.69%
Natulongan	427	60.48%	218	30.88%	61	8.64%
Pinamula	44	15.66%	161	57.30%	76	27.05%
Sanipon	29	15.18%	78	40.84%	84	43.98%
Talahiron	588	81.22%	97	13.40%	39	5.39%
Tumaras	166	71.55%	29	12.50%	37	15.95%
Dangcagan						
Dolorosa	44	22.34%	140	71.07%	13	6.60%
Miaray	353	52.61%	188	28.02%	130	19.37%
San Vicente	66	43.14%	56	36.60%	31	20.26%

Table 2-75 shows the sources of drinking water of the residents in the project site. In Barangay Tangkulan in the Municipality of Damulog, majority of the residents have access to Level II water sources (communal faucet). In the Municipality of Kibawe, residents in Barangays Bukang Liwayway, Magsaysay, Mascarinas and Sanipon have access to Level I water sources (point source). Residents in Barangays Balintawak, Cagawasan, Pinamula, and Tumaras has access to Level II water sources while in Barangays Natulongan, and Talahiron have access to Level III water sources (individual faucet). In the Municipality of Dangcagan, majority of the residents in Barangays Dolorosa and San Vicente have access to Level I water sources while in Barangay Miaray, half of the household have access to Level II water sources. There are also around 12 households that utilize water from unsafe sources. In the Municipality of Kitaotao, majority of the residents in Barangays Balocbocan and Tandong utilizes Level I water sources. Most of the residents in Barangays Kitaihon and Kitobo utilize Level II water sources while in Barangay San Vicente, half of the households have access to Level I water facilities.

Table 2-75: Source of Water

Barangay/ Municipality	Type of Water Facilities							
	Level III	%	Level II	%	Level I	%	Other Sources	%
Damulog								
Tangkulan	1	0.16%	607	99.84%				
Kibawe								
Balintawak			192	100.00%				
Bukang Liwayway					219	100.00%		
Cagawasan			208	100.00%				
Magsaysay					426	100.00%		
Mascarinas					147	100.00%		
Natulongan	708	100.00%						
Pinamula			281	100.00%				
Sanipon					191	100.00%		
Talahiron	724	100.00%						
Tumaras			182	100.00%				
Dangcagan								

Barangay/ Municipality	Type of Water Facilities							
	Level III	%	Level II	%	Level I	%	Other Sources	%
Dolorosa			9	5.06%	167	93.82%	2	1.12%
Miaray			341	50.00%	332	48.68%	9	1.32%
San Vicente			16	12.31%	113	86.92%	1	0.77%
Kitaotao								
Balocbocan	1	0.32%	2	0.63%	313	99.05%		
Kitaihon	32	29.91%	65	60.75%	10	9.35%		
Kitobo	12	2.69%	430	96.41%	4	0.90%		
Metebagao	13	10.24%	53	41.73%	61	48.03%		
San Lorenzo	62	50.00%	31	25.00%	31	25.00%		
Tandong	5	3.36%	16	10.74%	128	85.91%		

2.4.3.3 Power

Table 2-76 shows the availaiblty of electricity at the municipal level. Records show that in the Municipality of Kitaotao, 93.71% of the households have electricity, 74.32% in the Muncipality of Kiabwe, 47.16% in the Municipality of Damulog and 22.31% in the Municipality of Dangcagan.

Table 2-76: Availability of Electricity

	With Electricity	%	Without Electricity	%
Damulog	3,032	47.16%	3,397	52.84%
Kibawe	6,480	74.32%	2,311	26.29%
Dangcagan	1153	22.31%	4016	77.69%
Kitaotao	3218	93.71%	216	6.29%

2.4.3.4 Communication

Communication facilities are available in the municipalities. Table 2-77 shows the summary of available communication facilite by municipality. However, cellular and internet signal in remote areas of the municipalities are intermittent to unavailable. This communication facilities are mostly available in Poblacion/commercial areas.

Table 2-77: Communication Facilities

	Internet Service	Postal Service	Cellular Network	TV/Radio
Damulog	☑	☑	☑	☑
Kibawe	☑	☑	☑	☑
Dangcagan	☑	☑	☑	☑
Kitaotao	☑	☑	☑	☑

2.4.3.5 Transportation and Road Networks

Table 2-78 shows the road length by type in each municipality. Most of the available roads are gravel type. Road density (total road length relative to the land area of the municipality)is also shown in the table.

Table 2-78: Road Length and Density

Municipality	Road Length (km)					Land Area (ha)	Road Density
	Asphalt	Gravel	Concrete	Earth	Total		
Damulog	3.4550	88.5867	8.2583	110.3068	210.6700	24,566.00	0.0086
Kibawe	2.0000	135.5500	32.1100	35.0000	204.6600	39,692.00	0.0052
Dangcagan	6.4895	125.2216	12.1060	147.1929	291.0100	42,269.00	0.0069
Kitaotao		142.8480	2.3750	85.5170	228.3650	92,730.00	0.0025

2.4.4 Health and Local Health Resources

2.4.4.1 Local Health Resources

Table 2-79 and **Table 2-80** show the available health facilities and health personnel in each municipality. Available services include: Maternal Health, Neonatal Health, Child Health, Non-communicable disease control, Communicable disease management and control, Vector-borne disease control and management, Control of emerging and re-emerging disease, Health emergency management, Disease Surveillance, and Family Planning

Table 2-79: Health Facilities

	RHU	BHS	Day Care Center	Private Clinic	Dental Clinic
Damulog	1	17	17		
Kibawe	1	12		1	
Dangcagan	1	13		1	2
Kitaotao	1	18			

Table 2-80: Health Personnel

	Doctors	Nurses	Midwives	Sanitary Inspector	Medical Technologist	Dentist	BHWs
Damulog	1	1	26	1	1		
Kibawe	5	18	8		1		138
Dangcagan	1	1	17		1	1	109
Kitaotao	1	2	21	1	1	1	390

2.4.4.2 Morbidity and Mortality

The leading casues of Morbidity and Mortlaity is shown below in **Table 2-81** and **Table 2-82.** Acute Respiratory infection, upper respiratory tract infection and all type of wound are the top causes of morbidity in the project site. On the other hand, heart-related diseases, kidney-related diseases and cancer are the top causes of mortality within the project site.

Table 2-81: Leading Causes of Morbidlity

MUNICIPALITY OF DAMULOG									
2012		2013		2014		2015		2016	
CAUSES	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**
ARI-NP	**1,504**	ARI-NP	**1,848**	ARI-NP	**1,281**	ARI-NP	**1,090**	ARI-NP	**1,198**
WOUND ALLTYPES	283	WOUND ALLTYPES	341	WOUND ALLTYPES	363	WOUND ALLTYPES	681	WOUND ALLTYPES	389
UTI	224	UTI	282	UTI	255	UTI	140	UTI	475
PNEUMONIA	132	PNEUMONIA	306	PNEUMONIA	84	PNEUMONIA	322	PNEUMONIA	438
HYPERTENSION	118	HYPERTENSION	239	HYPERTENSION	83	HYPERTENSION	318	HYPERTENSION	391
DIARRHEA	68	DIARRHEA	73	DIARRHEA	82	DIARRHEA	48	DIARRHEA	44
SKIN ALLERGY	48	SKIN ALLERGY	48	SKIN ALLERGY	80	SKIN ALLERGY	128	SKIN ALLERGY	42
ANIMAL BITE	21	ANIMAL BITE	49	ANIMAL BITE	50	ANIMAL BITE	140	ANIMAL BITE	45
TB PULMONARY	29	TB PULMONARY	28	TB PULMONARY	43	TB PULMONARY	126	TB PULMONARY	18
URTI	26	URTI	0	URTI	0	URTI	550	URTI	89
AMOEBIASIS	0	AMOEBIASIS	16	AMOEBIASIS	0	AMOEBIASIS	0	AMOEBIASIS	50
SVI	0	SVI	0	SVI	145	SVI	180	SVI	452
TOTAL	**2,453**		**3,230**		**2,466**		**3,723**		**3,631**
MUNICIPALITY OF KIBAWEe									
2011		2012		2013		2014		2015	
CAUSES	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**
URTI	4,679	URTI	6,043	URTI	4,503	URTI	3,062	URTI	2,272
SVI	1,212	SVI	2,293	SVI	2,748	SVI	1,265	SVI	777
Acute bronchitis	980	Bronchitis	1,184	Bronchitis	925	Bronchitis	575	UTI	372
UTI	888	UTI	705	UTI	900	UTI	425	Bronchitis	361
Hypertension	475	Pneumonia	425	Acute respiratory infection	438	Pneumonia	221	Pneumonia	298
Gastritis	411	Gastritis	418	Pneumonia	427	Gastritis	215	Impetigo	265
Acute respiratory infection	371	ARI	468	Gastritis	382	Hypertension	197	ARI	233
Injuries	308	Hypertension	328	HPN	304	ARI	170	HPN	152
Acute lower gastroenteritis	222	Injuries	239	ARI	313	Age	158	Wounds	143
Arthritis	210	Wounds	237	Injuries	234	Wounds	143	Gastritis	122
Total	**9,756**		**14,352**				**6,431**		**4,995**
MUNICIPALITY OF DANGCAGAN									
2004		2005		2006		2007		2008	
CAUSES	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**	**CAUSES**	**Number**
Acute Respiratory Tract Infection	3,712	Acute Respiratory Tract Infection	1,563	Acute Respiratory Tract Infection	1,339	Acute Respiratory Tract Infection	806	Acute Respiratory Tract Infection	864
Renal Disease	992	Renal Disease	574	Renal Disease	478	Renal Disease	451	Renal Disease	307
Pneumonia	132	Pneumonia	449	Pneumonia	567	Pneumonia	426	Pneumonia	509
Diarrhea	206	Diarrhea	137	Diarrhea	210	Diarrhea	182	Diarrhea	156
Wounds	382	Wounds	109	Wounds	57	Wounds	151	Wounds	116

Skin Disease	322	Skin Disease	139	Skin Disease	68	Skin Disease	127	Skin Disease	104
Hypertension	420	Hypertension	262	Hypertension	82	Hypertension	95	Hypertension	68
Gastritis	661	Gastritis	84	Gastritis	58	Gastritis	43	Gastritis	35
Chicken Pox	20	Chicken Pox	41	Chicken Pox	10	Chicken Pox	23	Chicken Pox	15
Tonsilitis	40	Tonsilitis	35	Tonsilitis	37	Tonsilitis	41	Tonsilitis	22
Dog bite	26	Dog bite	17	Dog bite	22	Dog bite	73	Dog bite	53
Bronchitis	345	Bronchitis	81	Bronchitis	78	Bronchitis	93	Bronchitis	34
Tubercolosis	7,258	Tubercolosis	30	Tubercolosis	14	Tubercolosis	28	Tubercolosis	16
TOTAL	**14,516**		**3,521**		**3,020**		**2,539**		**2,299**

MUNICIPALITY OF KITAOTAO

						2008		**LAST 5 YEARS AVERAGE**	
						CAUSES	**Number**	**CAUSES**	**Number**
						Pneumonia	262	Pneumonia	489
						Diarrhea	291	Diarrhea	566
						Rabies	43	Rabies	0
						Influenza	139	Influenza	4
						TB-Respiratory	23	TB-Respiratory	42
						Hypertension	185	Hypertension	467
						Malaria	74	Malaria	56
						Malnutrition	59	Malnutrition	317
						Heterophydiasis	**6**	Heterophydiasis	**5**
						Leprosy	1	Leprosy	3
						TOTAL	**1,083**		**1,949**

Source: Comprehensive Land Use Plans/Rural Health Units.

Table 2-82: Leading Causes of Mortality

MUNICIPALITY OF DAMULOG									
2012		2013		2014		2015		2016	
CAUSES	Number	CAUSES	Number	CAUSES	Number	CAUSES	Number	CAUSES	Number
Cerebro Vascular Accident	**6**	Unkown Natural Cause	**10**	Cerebro Vascular Accident	**12**	Pneumonia	**10**	Cancer - all types	3
Coronary Artery Disease	7	Cancer - all types	7	Coronary Artery Disease	6	Myocardial Infarction	6	Accidents	1
Acute Renal Failure	5	Coronary Artery Disease	7	Pneumonia	6	Cancer - all types	5	Pneumonia	**11**
Cancer - all types	4	Cerebro Vascular Accident	6	Cancer - all types	5	Cerebro Vascular Accident	2	Sepsis	5
Pneumonia	4	Pneumonia	4	Pulmonary TB	3	Accidents	1	Pulmonary TB	2
Unkown Natural Cause	3	Accidents	2	Sytemic Lupos erythromatosus	1	COPD	1	Myocardial Infarction	2
Sepsis	3	Drowning	2			Stevens Johnson Syndrome	1	Acute Renal Failure	1
Post Partum Hemmorhage	2	Severe Dehydration	1			Drowning	1	Thyphoid Fever	1
Accidents	1	Post Partum Hemmorhage	1					Status Asthmaticus	1
Respiratory Failure	1								
Severe Dehydration	1								
Asphysia	1								
Severe Anemia	1								
COPD	1								
Hepatitis B	1								
Myocardial Infarction	1								
TOTAL	**42**		**40**		**33**		**27**		**27**

MUNICIPALITY OF KIBAWE									
2011		2012		2013		2014		2015	
CAUSES	Number	CAUSES	Number	CAUSES	Number	CAUSES	Number	CAUSES	Number
Septicemia	23	Myocardial Infarction	30	Septiccmia	37	Sepsis	43	Sepsis	51
Pneumonia	22	Sepsis	25	Cerebrovascular Accident	27	Pneumonia	18	Pneumonia - CAD	29
Cerebrovascular Accident	19	Acute Respiratory Infection	19	Myocardial Infarction	26	CVA, CVD	17	Myocardial Infarction	27
Myocardial Infraction	16	Intra cerebral Hemorrhage	16	Malignancy (All forms)	21	Cardio Vascular Disease	11	Cerebro Vascular Accident	24
Cancer, All forms	15	Cerebrovascular Disease	14	Pneumonia	17	Myocardial Infarction	9	Malignancy, All forms	15
Congestive Heart Failure	9	Congestive Heart Failure	8	Respiratory Distress Syndrome	15	Wounds	6	Acute Respiratory Failure	11
Chronic Kidney Disorder	9	Respiratory Distress	7	Congestive / Decompensated Heart Failure	13	Pulmonary Congestion	5	Congestive Heart Failure	10
End-Stage Renal Disease	7	Community Acquired Pneumonia	6	Intra Uterine Fetal Death	10	Infracranial Hgc	4	Chronic Obstructure	
Multiple Stabbed Wounds	6	Pneumonia	6	Chronic Obstructive		Asphexia	3	Pulmonary Disease	10
Vehicular Accidents	5	Cardiogenic Schock	5	Pulmonary Disease	5	Rheumatic Fever	3	Rheumatic Fever	10
Pulmonary TB	5	Renal Failure	5	Cardiogenic Schock	5	Diabetes	3	Stab Wound	4
Accidents Fall	5	Hypoxic Encephalopathy	5			Cardiogenic Shock		Infracranial Hqc	4

Cardiac Failure	5	Liver Cirrhosis	4					Intrauterine Fetal Death	4
Intra Cranial Hgc	5							Asphysia	3
TOTAL	**151**		**150**		**176**		**122**		**202**

MUNICIPALITY OF DANGCAGAN									
						2007		**2008**	
						CAUSES	**Number**	**CAUSES**	**Number**
						Heart Disease	5	Heart Disease	13
						Accident	5	Accident	13
						Pneumonia	3	Pneumonia	1
						Renal Disease	2	Renal Disease	1
						TOTAL	**15**		**28**

MUNICIPALITY OF KITAOTAO									
						2008		**LAST 5 YEARS AVERAGE**	
						CAUSES	**Number**	**CAUSES**	**Number**
						Accidents	18	Accidents	16
						Other Respiratory Disorder	8	Other Respiratory Disorder	6
						Hypertensice Disease	27	Hypertensice Disease	16
						Coronary Artery Disease	3	Coronary Artery Disease	2
						Cancer	4	Cancer	4
						PTB	2	PTB	3
						Diabetes	3	Diabetes	1
						Malnutrition	5	Malnutrition	7
						Renal Failure	5	Renal Failure	5
						Diarrhea	6	Diarrhea	3
						TOTAL	81		63

Source: Comprehensive Land Use Plans/Rural Health Units.

2.4.4.3 Endemic Diseases

In the Province of Bukdinon, malaria, filariasis, schistosomiasis, dengue, leprosy and other mosquito-borne diseases are considered endemic. Based on available information, cases of malaria have been recorded in the Municipality of Kitaotao. There are also records of the disease being present in the Municipality of Dangcagan. There is alos an on-going disease surveillance programs for malaria, filariasis and dengue in the Municipality of Dangcagan. Cases of leprosy have also been recorded in the Muncipality of Kitaoto. Cases of schistosomiasis were detected in the Cities of Valencia and Malaybalay but not in the municipalities of the project area. The same situation is true for cases of filariasis where it was detected in other parts of the Province but not in the municipalities of the Project area.

2.4.5 Main Sources of Income and Livelihood

Agriculture plays a major role as the main source of income and employment among the residents within the project site and the surrounding area.

Municipality of Damulog. The total municipal land area of Damulog is 24,057 hectares, 47.66% is agricultural lands. As of 2016, 60.19 percent of the total agricultural lands are utilized with corn having the biggest area and vegetables area with the lowest comprising 0.28% only. Corn planting is the most common crop adapted by farmers. This crop also has less laborious during vegetative until productive stage because of the adoption of round-up ready corn seeds which enable the farmer to use glyphosate herbicides.

Barangay Tangkulan rank first as the largest barangay in the production of corn with 1,350 hectares while Barangay Poblacion is the lowest having only 50 hectares because it was already populated in year 2016. Barangay Tangkulan has the largest area planted with corn and it follows that this barangay has the largest production with accumulation of 6,075 metric tons while barangay Poblacion has 225 metric tons only.

Municipality of Dangcagan. The municipality's economy is primarily agri-based with a total agricultural land of 9,346.7587 hectares accounting for 22.11 percent of the total municipal area.

Current crop production area covers 44 percent of the total agricultural lands. This is a slight decrease of 0.07 percent from the previous figure excluding crop production in the reclaimed areas. Commercial crops cover the biggest area of 1,856 hectares or 45.15 percent of the total 2007 crop area of 4,110 hectares, followed by corn comprising 38.92 percent. Root crops (1.46%) and vegetables (0.39%) cover the smallest of all the crops.

The crop production area registered a decrease of 3 hectares or 0.07 percent. Sugarcane showed the biggest decrease of 54 hectares due to the conversion of sugarcane areas to other commercial crops and other cash crops.

In terms of value, sugarcane had the biggest with 65.65% of the total production value while vegetables showed the lowest production value of 0.07 percent. Except for pineapple which is only planted commercially in two (2) barangays by multi-national corporations, the rest of the crops are planted in 12 to 14 barangays.

Municipality of Kibawe. Corn is the major crop grown in the locality, utilizing 5,165 hectares of the total agricultural land. Hybrid corn, Sige sige and open pollinated variety are the types of corn usually planted. 1,339 hectares is devoted to rice production in three ecosystems the irrigated, rain fed lowland and upland areas. Other agricultural crops include high valued commercial and industrial crops such as coconut, rubber, sugarcane, cassava and coffee utilizing 2,525.50 hectares. Moreover, banana is a growing industry in the locality utilizing 195.578 hectares of the land leased by DOLE Skyland plantation devoted to produce banana of good quality for export purposes and 193.422 hectares are planted by individual farmers producing lakatan, tundan and cardava banana for our

local market. Furthermore, assorted fruit trees, vegetables, legumes and root crops are also present in the locality and are produced in small scale.

Municipality of Kitaotao. The economy of Kitaotao is primarily agriculture based. Of the total municipal households, about 90% derived their main income from crops and livestock production. From the total number of farmers, about 0.5% have additional source of income from freshwater fish culture and extensive fishing in communal waters. The dissemination of agricultural technology is mainly provided by the Municipal Agriculture Office, which at present has eight personnel who have varied specializations to cater the needs of the farming populace disclosing a ratio of 1 technician per 769 farmers.

About 22.12 percent of the total land area of Kitaotao is arable or suitable for cultivation with rice and corn as the main staple crops. Sweet potato and cassava were usually grown for household's subsistence. However, the start of year 2008, cassava began to kick-off as one of the main industrial crops in Kitaotao, together with sugarcane, coconut, rubber and coffee. The fruit crops dominant in the area include banana, durian, mango, rambutan and lanzones.

2.4.5.1 Commercial Establishment and Activities

Table 2-83 shows the economic activities/establishment present in the municipalities and the number of employment for each activities/establishment.

Municipality of Damulog. There are two identified centers of commerce and trade in the Municipality located in Purok 3 and 9, both in Barangay Poblacion. A significant increase has been recorded in the total number of business establishments in the locale. Majority of the establishments are wholesale and retail trades comprising the biggest share in the commercial activities. Other economic activities boosting the business districts include Hotel and Restaurants, Transport & Storage, Financial Intermediation, Renting and Business Activities, and provision of basic social services.

Municipality of Dangcagan. Compared to other Municipalities in Bukidnon, Dangcagan is not yet fully developed in terms of commerce and trade. Since the whole area is agriculture-based, farmers used to flock to the market with their products for sale and go home with goods bought from other traders. Like any other central business districts, majority of commercial activities are dominated by wholesale and retail trade, transport and storage, and hotel and restaurants, and provision of basic social services.

Municipality of Kibawe. The emergence of small, medium, and large scale enterprises in the Municipality of Kibawe resulted in the increase of revenues in the business districts such as Poblacion and West Kibawe. Hot spot for the commercial activities are located in the public market. In the peripheral barangays, presence of slaughterhouse, public vehicle terminals, and small businesses like sari-sari store are very evident.

Municipality of Kitaotao. To support the Municipality's vision on agro-industrial development, the local government supports the active participation of commerce and trade of local goods. Most of these business enterprises are concentrated in Poblacion which serves as the urban center of the municipality. This limited services and facilities is a major factor for the consumers to go to the nearby municipality of Don Carlos where better options of goods and services are available. Aside from that, the municipality has both natural and cultural tourist attractions located at the forestall areas and are patronized by local and foreign tourists. This is also another revenue service that provides employment opportunities, aside from the agro-industrial plantations owned by landed community dwellers and multi-national corporations.

Table 2-83: Economic Activity and Number of Employment

Economic Activities	Damulog		Dangcagan		Kibawe		Kitaotao	
	2016		2008		2015		2016	
	No. of Establishment	No. of Employment	No. of Establishment	No. of Employment	No. of Establishment	No. of Employment	No. of Establishment	No. of Employment
Wholesale and Retail	139	120	129		49		543	
Hotel and Restaurants, Transport and Storage	4	20	124		14			
Communication			3					
Financial Intermediation	3	7	1		5		14	
Agri-Industries			9		15			
Renting and Business Activities	1	1						
Farming		3900		4420		6196		
Fishing		33				87		
Education	1	8						
Contractual Status								200
TOTAL	**148**	**4089**	**266**	**4420**	**83**	**6283**	**557**	**200**

2.4.5.2 Banking and Financial Institutions

Municipality of Damulog. According to the Comprehensive Land Use Plan 2017-2026 (CLUP) of the Municipality of Damulog, there are no existing credit facilities in the locale. The nearest credit facilities available are located at the Municipality of Kibawe. These are First Community Cooperative (FICCO), Sta. Catalina Cooperative and Rural Bank of Kibawe. These 3 credit facilities provide loan services to the farmers which is very helpful especially in the cooperative.

Municipality of Dangcagan. Based from the available data, there are operational banking/lending institutions in the municipality. These institutions provide financial aids to small business owners and farmers for capitalization. However, some of the borrowers find it hard to access credit from organized banking an institution due to some nuisances in their set policies and processes.

Municipality of Kibawe. Most farmers from the Municipality of Kibawe are dependent on the financing institution that offers lower rates of interest and less paper requirements. Credit and financial institution in the municipality includes FICCO, Sta. Catalina Credit Cooperative, Rural Bank of Kibawe, First Valley Bank, Asian Hills Bank and other private lending institution like TIBOD and ASA wherein they cater the financial needs of our farmers for crop production.

Municipality of Kitaotao. All farmers have access to raise capital through financing institution such as banks and cooperatives as an agricultural loan with low interest rate. There are 22 cooperatives in the municipality who offered such loan and one banking institution that is South Bank. Land Bank of the Philippines also granted agricultural loan to some farmers in the locality with banking office at Don Carlos, Bukidnon.

2.4.5.3 Poverty Incidence

Table 2-84 shows the small area proverty estimate based on information from the Philippine Statisitics authority. Records show that the Municipalities of DAmulog Kibawe and Kitaotao recorded poverty incidence which is higher than or equal to the poverty incidence at the provincial level. All municipalities have poverty incidence higher than the Philippines as a whole.

Table 2-84: Poverty Incidence

	Poverty Incidence
Philippines (2012)	25.2
Bukidnon (2012)	49
Municipality	
Damulog	64.0
Dangcagan	39.7
Kibawe	49.0
Kitaotao	64.1

**2012 Small Area Estimate*

Source: Philippine Statistics Auhtority

2.4.6 Perception Survey

Socioeconomic information and perceptions on the Proposed South Pulangi Hydroelectric Power Plant Project was obtained through the conduct of a household survey in the identified direct impact barangays. The household surveys were performed on the thirteen direct impact barangays from the Municipality of Damulog, Dangcagan, Kibawe, and Kitaotao. Barangay health workers from both communities were tapped to serve as enumerators, taking advantage of their superior knowledge of their own communities and neighbors. The survey was held last September 2018. A total of 313 respondents from different zones/purok were interviewed on a face-to-face and one-to-one basis. Respondents were chosen in the following order of preference:

- Household head (who may be male or female but always a resident-household member who makes the major household decisions or is perceived to do so; the household head is usually the father but may also be the mother or the eldest child who is of majority age (18 years old);
- Spouse of the household head;
- Son or daughter who is at least 18 years old of the household head; or
- Other relative who is at least 18 years old of the household head.

Also, the sampling was only held during daylight hours in light of safety and security considerations. The sample size was determined with a margin of error of ± 5 with a confidence level of 95%.

2.4.6.1 Respondent's Profile and Household Information

According to the survey results, there are almost the same total numbers of male (50.16 %) and female (49.84 %) respondents in the direct impact barangays. The highest percent share for males came from Barangay Natulongan in Kibawe (18.47%) and Kitubo in Kitaotao for females (17.95 %). Among these 313 respondents, 14.38 % came from the ages 25-29 years old and 13.74% from ages 60-64 years old. The least significant number of respondents is found in the ages between, 20-24 years old (6.07%) (Table 2-85).

Table 2-85: Age of the Respondents

Age	Frequency	Percentage
15-19	20	6.39
20-24	19	6.07
25-29	45	14.38
30-34	36	11.50
35-39	40	12.78
40-44	34	10.86
45-49	32	10.22
50-54	17	5.43
55-59	27	8.63
60-64	43	13.74
Total	**313**	**100.00**

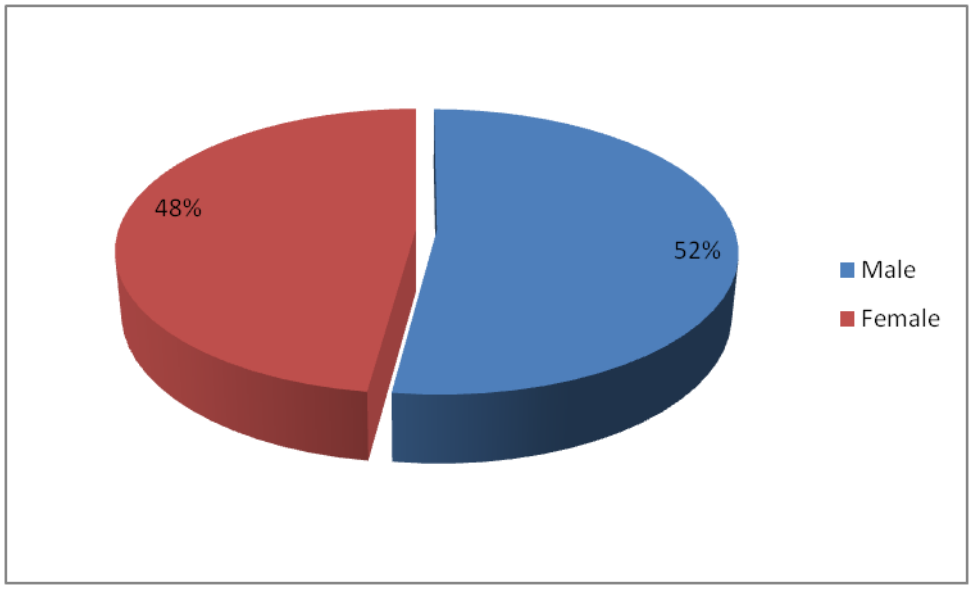


Figure 2-65: Gender of the Household Members

At the household level, there are more males (52%) than females (48%). The surveyed households' total dependency ratio (ratio of age 0-14 and >65 years old to 15-64 years old) is calculated at 68.93%. A lower dependency ratio generally implies that there is enough working age population (15-64) to support the economically dependent population (0-14 years old >65 years old). (
Table 2-86)

Table 2-86: Age of the Household Members

Age	Frequency	Percentage
0-4 yrs	133	9.55
5-9 yrs	176	12.64
10-14 yrs	192	13.79
15-19 yrs	146	10.49
20-24 yrs	108	7.76
25-29 yrs	79	5.68
30-34 yrs	108	7.76
35-39 yrs	83	5.96
40-44 yrs	86	6.18
45-49 yrs	65	4.67
50-54 yrs	61	4.38
55-59 yrs	33	2.37
60-64 yrs	55	3.95
65-69 yrs	32	2.30
75 yrs and up	18	1.29
70-74 yrs	17	1.22
Total	**1392**	**100.00**

In terms of civil status, most (86%) of the respondents are married and 10% are widows. Only 3% and 1 % of the total number of respondents are identified single and separated, respectively.

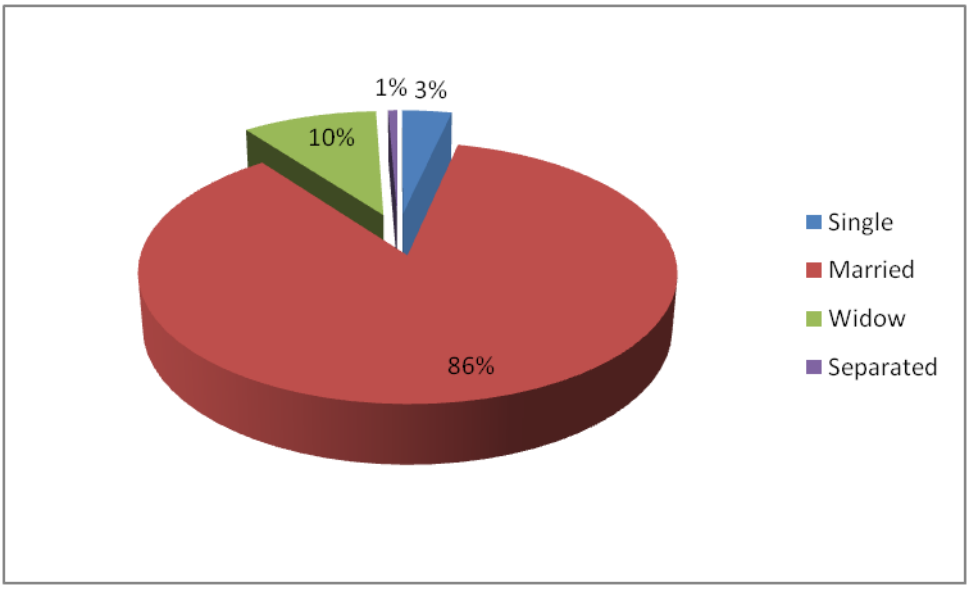


Figure 2-66: Civil Status of the Respondents

Highest educational attainment pertains to the highest level of education that an individual has completed. Among the household members aged 6-24 years old, 51.37% are reported to enroll and completed primary schooling, 38.40% for secondary schooling and 4.95 % at the college level. Many respondents are elementary graduates (24.19%) and elementary undergraduates (29.71 %). Individuals who do not experienced and afforded formal education is recorded at 1.92%. College undergraduates and graduates are identified at 0.64 %and 0.96%, respectively. Another noteworthy socio-cultural characteristic of a population is religion. In the surveyed area, most of the respondents are Roman Catholic (85.30%) while the remaining 14.7% belongs to other religious sectors as summarized in the table below.

Table 2-87: Highest Educational Attainment of the Respondents

Highest Ediucational Attainment	Frequency	Percentage
No formal education	6	1.92
Elementary level	93	29.71
Elementary graduate	101	32.27
High school level	61	19.49
High school graduate	47	15.02
College level	2	0.64
College Graduate	3	0.96
Total	**313**	**100.00**

Table 2-88: Religious Affiliation of the Respondents

Religion	Frequency	Percentage
Protestant	1	0.32
Born-again	1	0.32
Filipinista	1	0.32
Islam	1	0.32
Kristohanan	1	0.32
Seventh Day Adventist	1	0.32
Iglesias Filipinista	2	0.64
Baptist	6	1.92
Others (not specified)	8	2.56
Iglesia ni Cristo	10	3.19
Panubad	14	4.47

Religion	Frequency	Percentage
Roman Catholic	267	85.30
Total	313	100.00

Table 2-89 shows the length of residency of the respondents. According to the survey, most of the residents have been in their respective barangays for 31 years or more (40.89 %). Thirty one percent (31%) of the total number of respondents have also found out to live outside of their current residences. The percentage of the detailed location of their previous residences is shown in **Figure 2-67.**

Table 2-89: Length of Residency of the Respondents

Years of Residency	Frequency	Percentage
0-5 yrs	23	7.35
6-10 yrs	27	8.63
11-15 yrs	29	9.27
16-20 yrs	33	10.54
21-25 yrs	35	11.18
26-30 yrs	38	12.14
31 yrs and above	128	40.89
Total	**313**	**100.00**

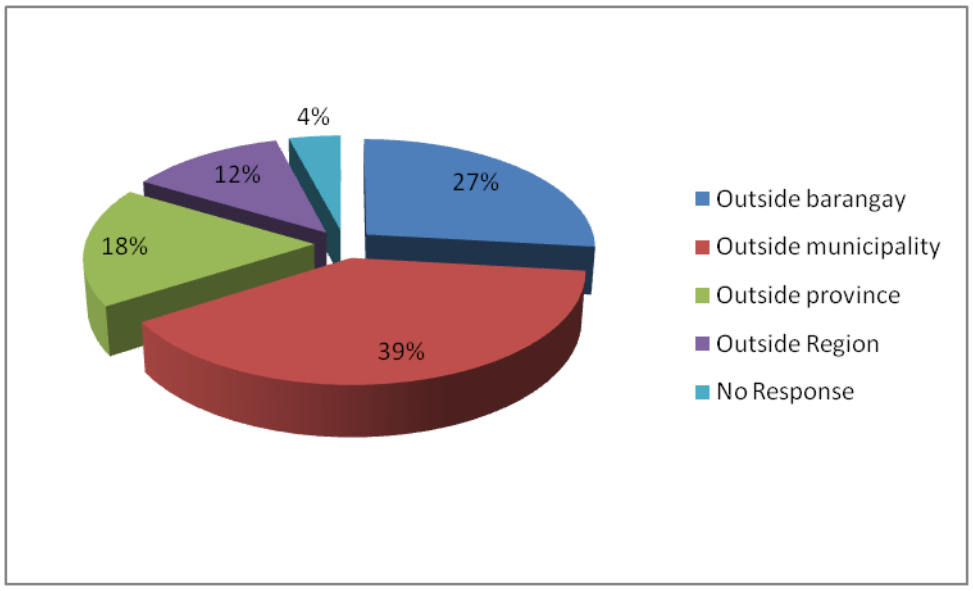


Figure 2-67: Previous Residence of the Respondents

2.4.6.2 Income and Employment

The predominant source of livelihood in the host communities is farming (53.24%) and employment (provision of service) at 15.24%. Using the recorded declarations, the average monthly household income was computed at PHP 13190 while the average monthly expenses for different items was shown in **Table 2-91.**

Table 2-90: Sources of Income of the Household Members

Source of Income	Frequency	Percentage
Employed	73	15.24
Self-employed	10	2.09
Professional	1	0.21
Fishing	23	4.80
Farming	255	53.24
Business	23	4.80
Land Rent	2	0.42
Stocks /Dividends	2	0.42
Pension	5	1.04
Others	85	17.75
Total	**479**	**100**

Table 2-91: Average Monthly Household Expenses

Item	Average Expenses
Food	1928
Education	1340
Groceries	924
Electricity	351
Water	166
Clothing	952
Recreation	330
Tax	721
Loans	1543
Rentals	**1000**

All owned and existing agricultural lands within the area are calculated at an average of 2 hectares. Majority of these agricultural lands are rain fed (89.74%) while a little portion of these lands are irrigated (10.26%). In a year, most of the crops are planted in two seasons. These plants include corn, rice, coconut, banana, rubber, cocoa, and peanut.They were all use for both subsistence and commercial products.

2.4.6.3 Health and Sanitation

As revealed by survey results, most of the residents opt to avail medical services provided by the Provincial (93.13%), Barangay Health Centers (50.38%), and Albularyo (42.75%).Respondents also mentioned that the common medicines they are taking include paracetamol, alaxan, and neozep which are usually bought from drug stores.

Table 2-92: Availed Medical Service by the Residents in the Direct Impact Barangays

Availed Medical Services	Frequency	Percentage
Espiritista	1	0.76
Private Hospital	27	20.61
Municipal Health Center	41	31.30
Albularyo	56	42.75
Barangay Health Center	66	50.38
Provincial Health Center	122	93.13
Total	**131**	**100.00**

There were seventeen (17) recorded deaths in the surveyed households. These deaths among the surveyed areas were mainly caused by diseases including, kidney failure, asthma, typhoid fever, heat

failure, myoma, symptoms of tuberculosis, and prematurity (for infants). Majority of deaths are recorded in the productive age group and elders.

Table 2-93 Type of Toilet Facility

Type of Toilet	Frequency	Percentage
No toilet	34	10.86
Dug Hole	59	18.85
Sanitary Pit Privy	200	63.90
Unsanitary Pit Privy	20	6.39
Total	**313**	100.00

Most of the households have access to sanitary pit privy (63.90%), however, there still households who do not have access to any type of toilet facility (10.86%) as seen in Table 2-93. When it comes to drinking water, residents are more dependent on communal supply of water (52 %) than the household water supply.

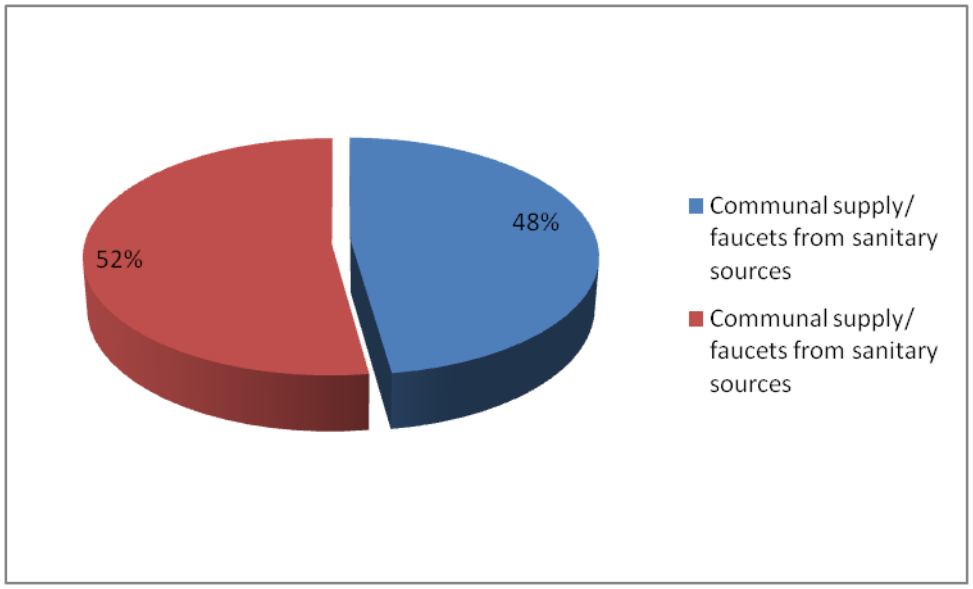


Figure 2-68: Source of Drinking Water in the Direct Impact Barangays

The conducted household survey in host barangays reveals that a larger percentage (55.91%) resorts to burning as their method of waste management. Other waste management practices being done by the residents are presented in **Table 2-94.**

Table 2-94: Waste Management Practices in the Direct Impact Barangays

Waste Management	Frequency	Percentage
Open pit	122	38.98
Burning	175	55.91
Thrown on the River	9	2.88
Thrown everywhere	3	0.96
Others	4	1.28
Total	**313**	100.00

2.4.6.4 Household Assets and Housing Characteristics

In host barangays, houses have an average of two (2) rooms and one (1) bed room. These houses' walls and floors are built with different materials as shown in Table 2-95 and Table 2-96, respectively.

Table 2-95: Used Walling Materials

Material	Frequency	Percentage
Wood	195	0.32
Concrete	72	2.24
Nipa/ Cogon	7	12.14
Makeshift	1	23.00
Bamboo	38	62.30
Total	**313**	**100.00**

Table 2-96: Used Flooring Materials

Material	Frequency	Percentage
Soil	25	7.99
Wood	64	20.45
Bamboo	124	39.62
Plant cement	99	31.63
Tiles/Marbles	1	0.32
Total	**313**	**100**

In terms of the light source, majority of the households are dependent on electricity (70 %) while only 30 % are still using gas lamp. On the other hand, most of the residents are still into firewood (68%) as fuel in cooking and food preparation **Figure 2-70.**

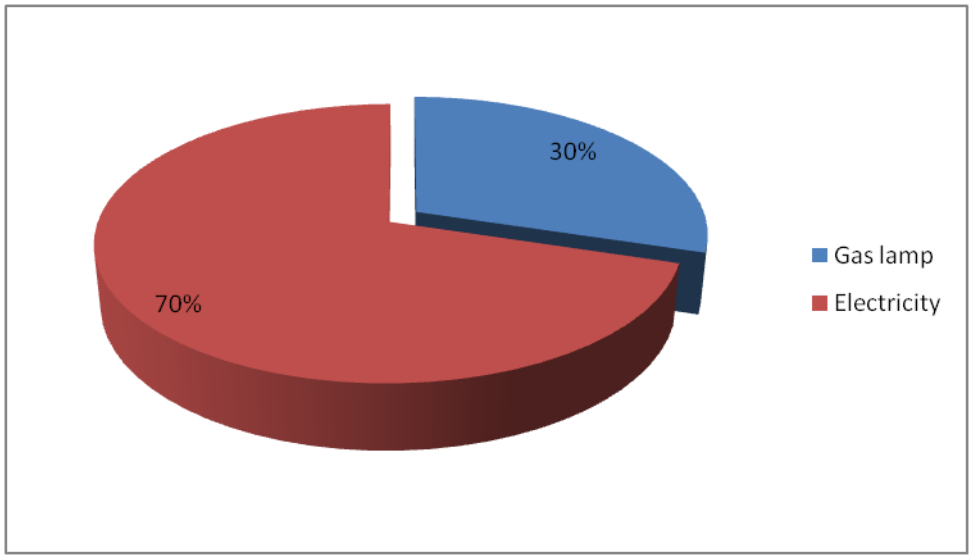


Figure 2-69: Lighting Source of the Surveyed Households

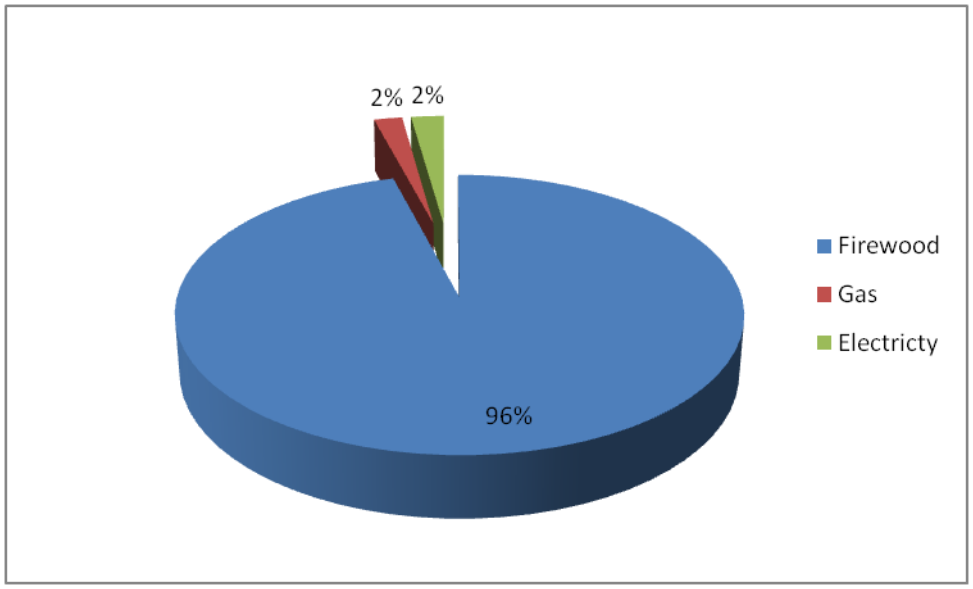


Figure 2-70: Fuel for Cooking

2.4.6.5 Perception of the Project

Primarily, respondents' knowledge on the proposed project was asked to further determine their perceptions. As revealed, there are more residents who are knowledgeable on the proposed project (81%) than those who are not (19%) (**Figure 2-71**). Majority of information known by the communities came from local officials at the barangay level (80.71%) **(Figure 2-72**). Enumerated below is the common knowledge of respondents on the proposed project:

- Dam for electricity-generation
- The project will be beneficial for majority but in expense of some residents (livelihood and settlements).
- Complete compensation packages will be delivered to directly impact households.
- The project can be damaging to the existing natural resources.

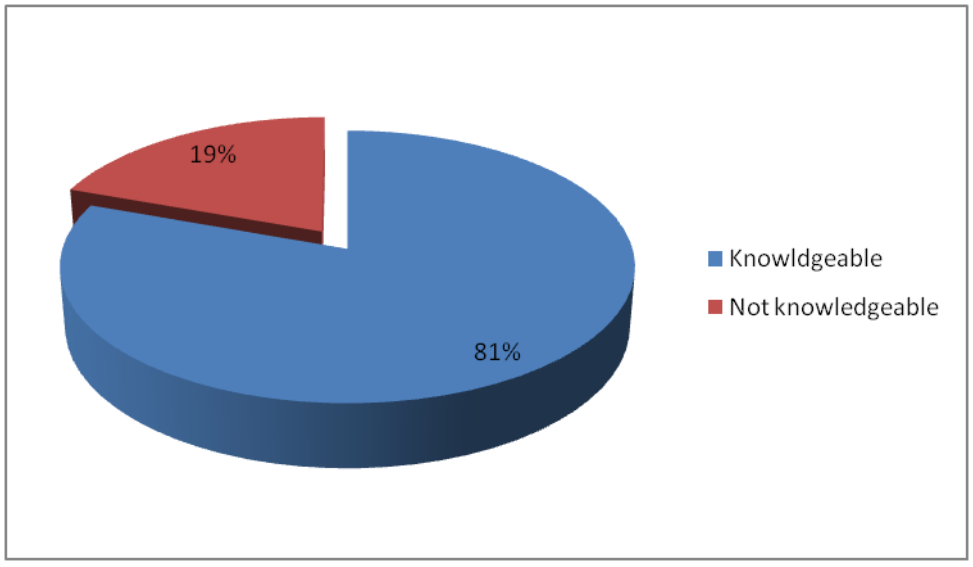


Figure 2-71: Knowledge of the Respondents on the Proposed Project

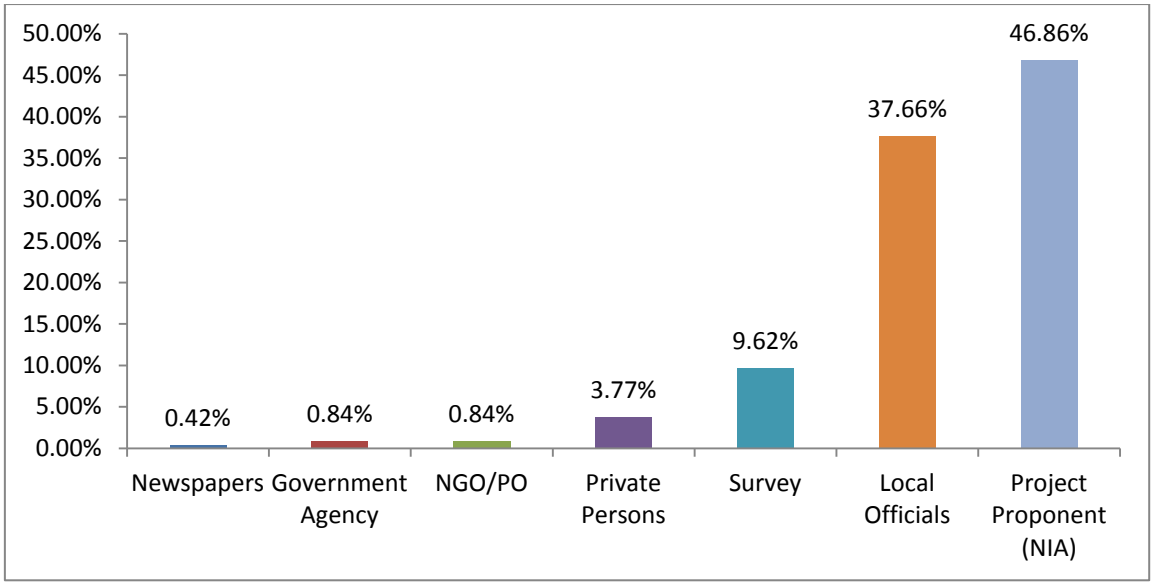


Figure 2-72: Sources of Information

When asked with question, "What are the possible positive effects of the proposed project?" Respondents identified additional income (80.56%), electricity and additional employment both at 7.78) as the top three possible positive effects of the proposed project (**Figure 2-73**). With the strong issues on the proposed project's negative impacts, especially on resettlement and environmental destruction, the respondents provided the following mitigating measures:

- The project should be reconsidered.
- Relocation and restoration of livelihood for the affected households must be the priority.

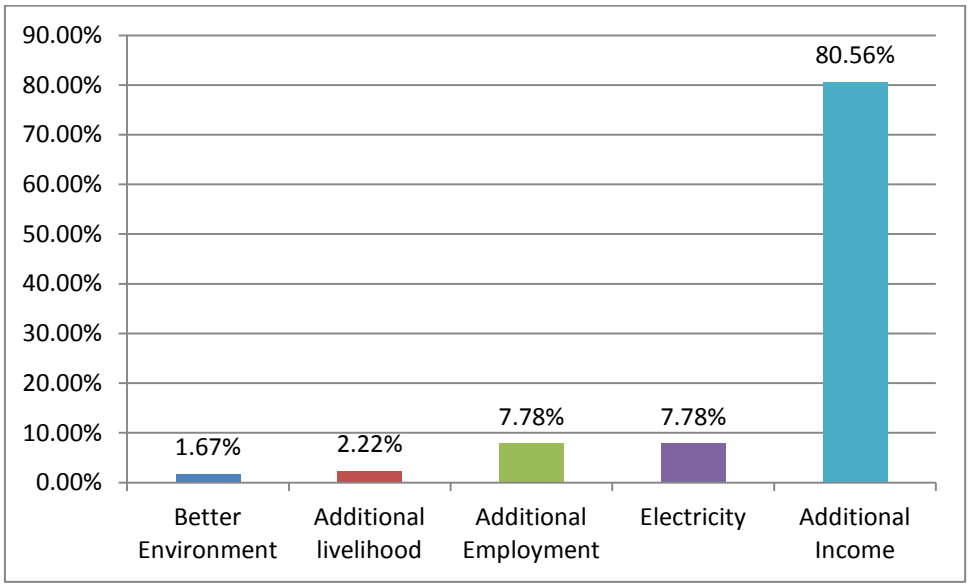


Figure 2-73: Perceived Benefits of the Project

General comments related to the proposed project are also incorporated in the crafted survey instrument. When asked about their recommendations and views on the proposed project at different phases/ stages, the respondents raised the following comments:

- If the project materializes, the proponent should provide houses, livelihood, and source of income, and restore or better off the living condition of the affected communities.
- Land and properties should be evaluated and given rightful and just compensation.
- The project is good as it will provide additional supply of electricity.
- The project is good as long as there will be no affected residents.
- Majority of the people in the affected communities are not in favor of the project.

2.4.7 Public Participation Activities

Table 2-97 shows the summary of IEC and public participation activities conducted.

Table 2-97: Summary of IEC Activities

Date	Activity	Venue	Participants
July 24, 2018	Project Presentation (LGU-PHPC initiated)	Maramag Gymnasium, Maramag Bukdinon	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders
August 7, 2018 9:00 am	Project Presentation EIA Process Presentation	Function Hall, Municipality of Damulog	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads
August 7, 2018 1:00 pm	Project Presentation EIA Process Presentation	Municipal Gymnasium, Municipality of Kibawe	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads
August 8, 2018 9:00 am	Project Presentation EIA Process Presentation	Lucky 9 Resort Municipality of Dangcagan	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads
August 8, 2018 1:00 pm	Project Presentation EIA Process Presentation	Municipal Tennis Court, Municipality of Kitaotao	Local Government Units (Municipal) Barangay LGUs Tribal Leaders/Elders Women's Organization Senior Citizen's Organization Youth Organization Community Leaders School Heads

2.4.7.1 IEC Municipality of Damulog

The IEC for the Municipality of Damulog was conducted last August 7, 2018 at 9:00am at the Municipal Function Hall. A total of 33 participants attended the event. The project covers one barangay in the Municipality of Damulog covering a portion of the reservoir area, dam area and power house. **Table 2-98** shows the summary of issues and concerns raised during the activity.

Table 2-98: Summary of Issues and Concerns Municipality of Damulog

Person/Sector Who Raised Concern	Issue and Concern Raised	Response
Tribal Leader, Brgy Tankulan	The project should be a venue to lift them from poverty. The project's benefit should reach them (IPs).	As mentioned, there will be a Php25, 000/ha/year land rental. In addition, there will be an allocation of 0.01KwH amounting to Php10M to be divided to the Province, Municipality and Barangay and additional 0.02KwH amounting to Php21.6M annually for the affected landowners. This will benefit the affected communities.
MENRO Damulog	In 2012, there was already an EIS study conducted for the Pulangi V project. How is this different? Also, the Municipality has recently updated our Comprehensive Land Use Plan. How will this project affect our CLUP?	The location of the proposed project is different from the proposed Pulangi V. The project is 7-8km upstream of the then-proposed Pulangi V. Hence, a new study is needed for the project.
Tribal Member	Until when will the Php 25,000/ha/ year be received? Is there a limit? Renewal?	This will be based on what will be agreed upon but initially, a 25-year initial contract is proposed, renewable for another 25 years.
Tribal Member	What will happen to affected schools? Trees?	All infrastructure that will be affected (school, stage, basketball courts, chapel, roads, bridges) will be replaced and improved. All affected lands including improvements (crops, trees) will be compensated.
Tribal Member	There should be relocation and employment first before the start of any construction activities.	Relocation of affected households will be done prior to construction to ensure their safety.
Barangay Official	What will happen to boats that use the river for access once the dam is constructed?	Alternative access roads will be constructed; affected bridges will be replaced and improved.
Tribal Member	How about those IP communities still without CADT (under application)? How will they be able to allow the company rent the land?	The LGU will assist in fast-tracking the CADT application of the IP communities.

Figure 2-74: Photodocumentation Municipality of Damulog IEC

2.4.7.2 IEC Municipality of Kibawe

The IEC for the Municipality of Kibawe was conducted last August 7, 2018 at 1:00 pm at the Municipal Gymnasium. A total of 90 participants attended the event. The project covers ten barangays in the Municipality of Kibawe covering a portion of the reservoir area. **Table 2-99** shows the summary of issues and concerns raised during the activity.

Table 2-99: Summary of Issues and Concerns Municipality of Kibawe

Person/Sector Who Raised Concern	Issue and Concern Raised	Response
Barangay Official Natolungan	Is it possible to advance payment for the Php 25,000/ha/year rental	This will be forwarded to top management for their consideration.
Barangay Official	When will the replacement schools be built if the construction is for 5 years?	All housing units and infrastructure (school, bridges, barangay halls, courts, stage, roads) will be replaced/relocated before start of construction.
Tribal Leader	Who is the proponent of the Project? PHPC or FIBECO? What is the relationship of PHPC and FIBECO?	The Proponent is PHPC. There is an agreement between PHPC and FIBECO to develop the project.
Tribal Leader	There should undergo the FPIC since the areas concerned are IP areas.	The FPIC under NCIP policies will be observed. Dr. Tess De Guzman, the anthropologist of LTI, will coordinate with the NCIP to secure the FPIC.
Tribal Member	Cultural Heritage Impact Assessment should be included in addition to the EIA.	This will also be conducted and undertaken by Dr. De Guzman. Participation of the IP communities will be emphasized during the assessment to ensure that cultural heritage-related concerns will be sufficiently addressed and programs will be in place for the IPs.
Tribal Member	There should be relocation before the project starts.	Relocation for the affected households and other infrastructure (schools, roads, bridges, barangay halls, chapels) will be undertaken prior to construction.
Brgy Captain Magsaysay	There should be barangay level consultation.	This is noted and will be coordinated with the LGU for scheduling.
Tribal Member	What will happen to those who have “palukso” (fishing gear) in the area?	As mentioned in the presentations, livelihood development is part of the program that will be implemented. This includes development of fisheries area for livelihood.
Tribal Leader	The first survey/drilling contractor has not yet paid some of the	This will be discussed/raised with FIBECO.

	laborers (under FIBECO). This should be settled.	
Tribal Leader	The MOU between the IPs and FIBECOM must be amended/revisited if PHPC will be the ones to construct/operate the project.	This will be forwarded to PHPC management. We can schedule a separate meeting to discuss this with FIBECO.
Barangay Official	Will there be increase in rental after 5-years?	This will be forwarded and discussed with PHPC management.

Figure 2-75: Photodocumentation Municipality of Kibawe IEC

2.4.7.3 IEC Municipality of Dangcagan

The IEC for the Municipality of Dangcagan was conducted last August 8, 2018 at 9:00 am at Lucky 9 Resort, Dangcagan. A total of 52 participants attended the event. The project covers three barangays in the Municipality of Dangcagan covering a portion of the reservoir area. **Table 2-100** shows the summary of issues and concerns raised during the activity.

Table 2-100: Summary of Issues and Concerns Municipality of Dangcagan

Person/Sector Who Raised Concern	Issue and Concern Raised	Response
Barangay Kagawad	Is it possible to have advance payment for lands affected?	One suggestion is to have 5 years advance and 1 year signing bonus but this will be subject to approval of management.
Barangay Kagawad	What will happen to those whose house/land will be affected but with no title?	If there are other proof of tenure (i.e., tax declaration, certificate of stewardship) this can be acceptable proof for compensation
Barangay Kagawad	How about those who source their livelihood from the river?	Aside from the rental agreement, affected households will be prioritized for employment and for the livelihood development to compensate for the loss of productive land.
Tribal Leader	Are there plans for the cemetery that will be affected?	This will be compensated and replaced.
Tribal Leader	How will the payment/benefits be given if the CADT is still under process?	The LGU will assist in fast tracking the CADT applications.
Barangay Kagawad	What specific areas will be submerged/ compensated?	At present, parcellary survey is on-going and 80% complete. Once complete, this will be presented to the affected owners for verification.
Barangay Captain	How many will be affected in Barangay San Vicente?	As mentioned, this will be determined upon completion of the parcellary survey.
Tribal Leader	There should be a MOA for the priority employment for IPs	This could be included in the endorsement resolution.
Barangay Kagawad	What will happen if the land affected has crops/coconut planted?	All improvement on land (crops/coconuts planted) will be compensated.
Barangay Kagawad	What will happen after 25 years of land rental?	The agreement can be renewed for another 25 years and will be negotiated with the affected owner.

Figure 2-76: Photodocumentation Municipality of Dangcagan IEC

2.4.7.4 IEC Municipality of Kitaotao

The IEC for the Municipality of Kitaotao was conducted last August 8, 2018 at 1:00 pm at the Municipal Tennis Court, Municipality of Kitaotao. A total of 58 participants attended the event. The project covers six barangays in the Municipality of Dangcagan covering a portion of the reservoir area. **Table 2-101** shows the summary of issues and concerns raised during the activity.

Table 2-101: Summary of Issues and Concerns Municipality of Dangcagan

Person/Sector Who Raised Concern	Issue and Concern Raised	Response
Barangay Kagawad	Land-if I have 2 ha of land that will be affected will there be livelihood provided?	The land will be rented for Php25,000/ha/year. In addition, qualified affected residents will be prioritized for employment. Also, livelihood development is part of the commitment of the company.
Barangay Kagawad	About the survey (parcellary) conducted it has not reached our area. We were initially informed that our area will be part of the affected.	At present, parcellary survey is on-going and 80% complete. Once complete, this will be presented to the affected owners for verification.
SB Member	Will the Barangay Hall of Metibegao be affected? In the Pulangi V Project, the Barangay Hall will be affected.	The Pulangi V project has a higher dam height to generate 300MW and hence more submerged areas. This project has a lower dam height.
Barangay Captain	The parcellary survey has not yet reached Barangay San Lorenzo.	At present, parcellary survey is on-going and 80% complete. Once complete, this will be presented to the affected owners for verification.
Barangay Kagawad	Is there a possibility of increasing the Php25,000 land rental say after 5 years?	This will be forwarded to management and negotiated with the landowners.

Figure 2-77: Photodocumentation Municipality of Kitaotao IEC

2.4.8 Key Impacts

2.4.8.1 Displacement of Settlers and Properties

The project will entail the construction of a dam and power house facilities to generate hydropower. Several household, trees, crops, local facilities and other lot improvements will be affected as a result of the construction and operation of the project. To this end, the Proponent will enter into negotiations with the concerned land/property owners once the final alignment of the Project has been established. The Proponent will negotiate the rightful compensation based on applicable laws and government procedures. The Proponent will establish a committee for this purpose whose main task will include the following:

i. identification and inventory of affected properties/houses/lands
ii. identification of appropriate compensation (amount) and compensation scheme (type, frequency)
iii. establishment of grievance redress procedures
iv. establishment of compensation and grievance redress monitoring procedures

The reservoir of the project area is initially estimated at 2,878 ha. Preliminarily identified to be affected are the following structures/improvements:

Table 2-102: Preliminary Affected Household and Infrastructure

Municipal	No. of Affected Households	Infrastructure
Damulog	61	0
Kibawe	599	14
Kitaotao	32	3
Dangcagan	9	0
Total	**701**	**17**
Infrastructure	**No. Affected**	
Barangay Hall	3	
School	3	
Chapel	3	
Bridge	8	
Total	**17**	

Part of the proponent's commitments to the host communities, in addition to complying with all relevant laws and processes, are the following:

a) Prioritizing the hiring of qualified local host constituents during the course of the construction of the hydropower plant;
b) Allocate Php .02/kWh above and beyond ER 1-94 to host communities;
c) Relocation will be given for those affected households within a safe zone to be provided by PHPC;

d) For those directly affected areas, PHPC offers rental for host land owners and IPs amounting to Php 25, 000.00 per hectare per year;
e) Should there be improvements affected such as but not limited to agricultural products, just compensation shall be offered in accordance with assessed value from the Municipal Assessor's Office;
f) Replacement by PHPC of affected infrastructure such as schools, barangay halls, chapels, health centers, ancestral domain and cultural heritage of Indigenous Peoples, etc.;
g) PHPC undertakes to locate the optimum placement of new improved roads and bridges which will be beneficial for the surrounding communities for them to have proper access to their respective areas; and,
h) Implementing a continuing social development program by PHPC hand in hand with the Province by giving training, livelihood and environmental rehabilitation programs.

2.4.8.2 In-Migration

Potential in-migration growth may be experienced as a result of project implementation in areas where the dam will be constructed due to demand of workers not only from affected barangays for labor and other skilled workers but also from other areas, for other labor requirements (laborers, mechanics, welders, etc.) that cannot be supplied by the locals. As there will be potential business opportunities for commercial and personal and recreational services, informal settlers may be attracted to potential jobs that will be indirectly created.

2.4.8.3 Change in Lifestyle

Life style change would be inevitable for both the direct and indirect impact areas. Those who will be relocated will meet initial economic difficulties at the relocation sites due to period of recovery from making productive agricultural replacement land and therefore will affect their affordability in accessing previous services and recreational services. In addition, they will have to save for some emergencies as well as possible increases in social services such as tuition fees, transportation and basic commodities. For the indirect impact areas, limitation in accessing forest resources and potential decrease in kaingin activities due to conservation and watershed management activities.

2.4.8.4 Impacts on Physical Cultural Resources

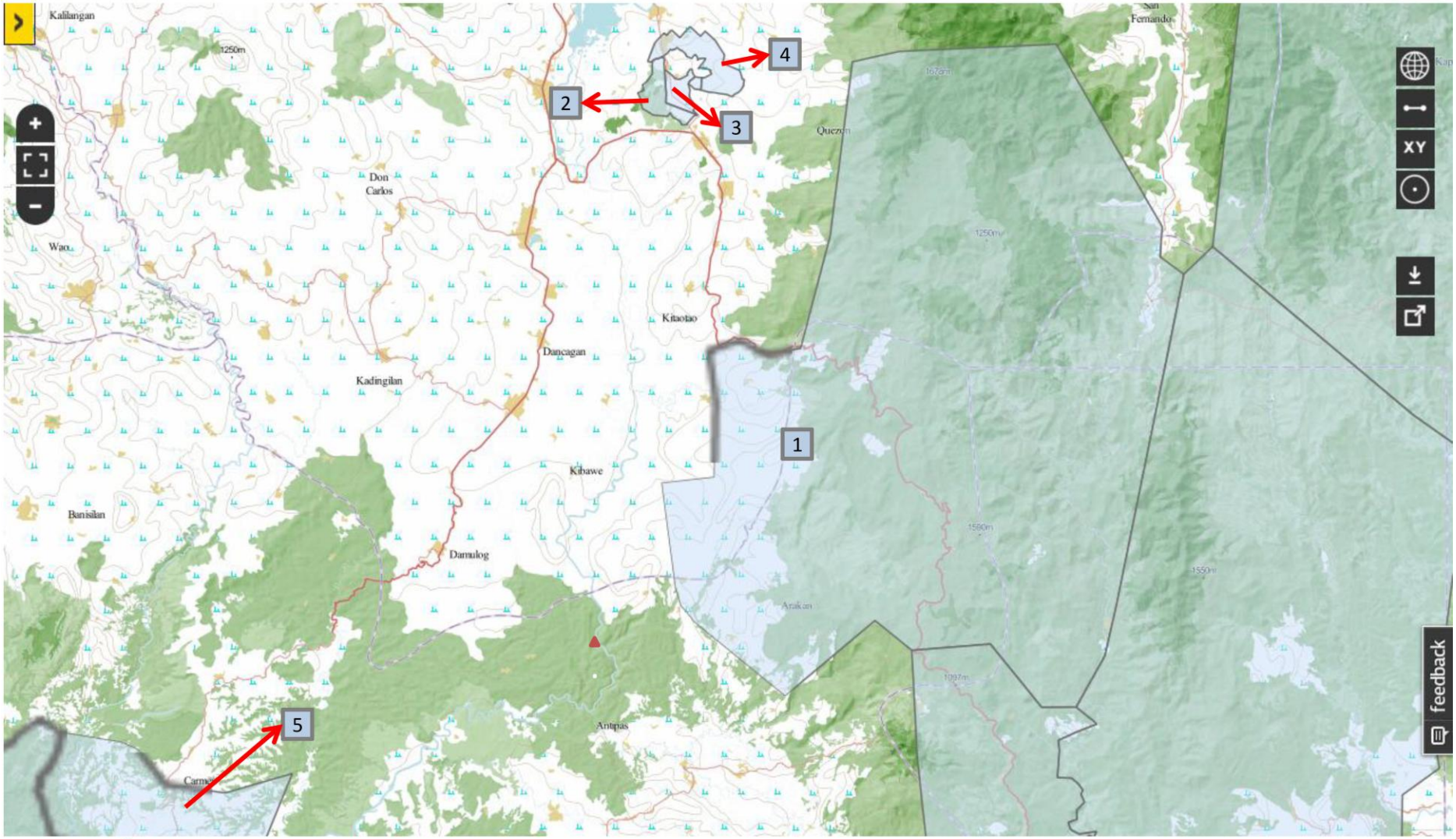
2.4.8.4.1 The Manuvu

Manuvu or the Manobos prefer the high places, the slopes and side of hills and mountains, to the level lands. The Manuvus are located Kitaotao, Kibawe, and Dangcagan. These tribes of people are bearers of the wealth of ethnic, cultural, spiritual and social diversity of Bukidnon.

According to Opena (1985), Manobo is a generic term which refers to people who are still in the subsistence level economy and are generally in the mountains and who practice the slash and burn agriculture. On the other hand, Elkins (1977) described the Manobo belongs to the original stock of proto-Philippines or proto-Austronesian people who came from South China thousands of years ago. He later coined the term Manobo to designate the stock of aboriginal non- negeritoid people of Mindanao. They mostly inhabit the hinterlands of Bukidnon specifically on the boundaries of Agusan, Bukidnon, Cotabato, Davao and Misamis Oriental (NCIP,2003).

2.4.8.4.2 Ancestral Land

As per report submitted by the Office of the National Commission on Indigenous Peoples, there were three (3) certificates of ancestral domain titles already issued within the Municipalities of Kibawe and Quezon, Bukdinon covering an area of 102,324.84.82 hectares, 624.71 hectares and 1,162.564 hectares respectively.



Dam site

	CADT/CADC No.	Tribe	Area (ha)	Date Approved
1	R10-KIT-0703-0011	Matigsalug-Manobo	102, 324.82	7/25/2003
2	R10-QUE-0712-159	Manobo	624.71	7/12/2012
3	CADC-135	Manobo	379.535	2/18/2004
4	R10-QUE-0204-018	Manobo	1162.564	2/18/2004
5	R12-MAT-0116-202	Erumanen ne Menuvu	48674.4384	1/26/2016

Lichel Technologies, Inc.
Unit 1403 Prestige Tower Condominium
F. Ortigas, Jr. Road, Ortigas Center, Pasig City

FIGURE TITLE :

CADC/CADT near the Project Site

FIGURE NO.:

2-76

2.4.8.4.3 Research Areas

Dangcagan is a municipality in the landlocked province of Bukidnon. The municipality has a land area of 422.69 square kilometers or 163.20 square miles which constitutes 4.03% of Bukidnon's total area. Its population as determined by the 2015 Census was 23,723. This represented 1.68% of the total population of Bukidnon province, or 0.51% of the overall population of the Northern Mindanao region. Based on these figures, the population density is computed at 56 inhabitants per square kilometer or 145 inhabitants per square mile. The municipal center of Dangcagan is situated at approximately 7° 37' North, 125° 0' East, in the island of Mindanao. Elevation at these coordinates is estimated at 357.5 meters or 1,172.6 feet above mean sea level.

Based on the great-circle distance (the shortest distance between two points over the surface of the Earth), the cities closest to Dangcagan are Valencia, Malaybalay, Kidapawan, Panabo, Davao City, and Marawi. The nearest municipalities are Kitaotao, Kibawe, Don Carlos, Kadingilan, Damulog, and Maramag. Its distance from the national capital is 888.42 kilometers (552.04 miles). The following list delineates such distance measurements.

Kitaotao is a municipality in the landlocked province of Bukidnon. The municipality has a land area of 788.78 square kilometers or 304.55 square mil es which constitutes 7.51% of Bukidnon's total area. Its population as determined by the 2015 Census was 50,260. This represented 3.55% of the total population of Bukidnon province, or 1.07% of the overall population of the Northern Mindanao region. Based on these figures, the population density is computed at 64 inhabitants per square kilometer or 165 inhabitants per square mile.

The population of Kitaotao grew from 14,708 in 1970 to 50,260 in 2015, an increase of 35,552 people. The latest census figures in 2015 denote a growth rate of 0.30%, or an increase of 772 people, from the previous population of 49,488 in 2010.

Based on the great-circle distance (the shortest distance between two points over the surface of the Earth), the cities closest to Kitaotao are Valencia, Malaybalay, Kidapawan, Panabo, Marawi, and Tagum. The nearest municipalities are Dangcagan, Don Carlos, Kibawe, Kadingilan, Maramag, and Quezon. Its distance from the national capital is 885.79 kilometers (550.40 miles). The following list delineates such distance measurements.

Kibawe is a municipality in the landlocked province of Bukidnon. The municipality has a land area of 304.13 square kilometers or 117.43 square miles which constitutes 2.90% of Bukidnon's total area. Its population as determined by the 2015 Census was 39,612. This represented 2.80% of the total population of Bukidnon province, or 0.84% of the overall population of the Northern Mindanao region. Based on these figures, the population density is computed at 130 inhabitants per square kilometer or 337 inhabitants per square mile.[5]

The population of Kibawe grew from 35,728 in 1960 to 39,612 in 2015, an increase of 3,884 people. The latest census figures in 2015 denote a growth rate of 1.96%, or an increase of 3,845 people, from the previous population of 35,767 in 2010.

The municipal center of Kibawe is situated at approximately 7° 34' North, 124° 59' East, in the island of Mindanao. Elevation at these coordinates is estimated at 371.3 meters or 1,218.0 feet above mean sea level.

2.4.8.4.4 Archaeology

Archaeologically speaking, central Mindanao is *terra incogita*. Many Manuvu' village are undoubtedly old, though they practice shifting agriculture. The Manuvu' were already in the area in pre-Spanich

times, long before the introduction of Islam for they show very little Islam influence. Majul (1965 in Manuel 1973) estimates that Arab traders who started missionary fourteen centuries and Saleeby (1905 in Manuel 1973) think that the sultanate must have been introduced by in the middle of the fifteenth century.

The Manobos of Mindanao Garvan (1931 in Manuel 1973), were the early settlers of the Pulangi River.

Opponents of the project have found an antidote to the project by asking the National Museum of the Philippines to declare sitio Mikasili in Barangay Tangkulan in Damulog, Bukidnon as a historical site. The move irked project proponents, saying it was "baseless and unnecessarily disrupting the mediation process to reconcile the rift that developed in the *lumad* community as a result of the proposed dam project."

A respected anthropologist and archeologist, Dr. Erlinda Burton, joined the press conference of those opposed to the declaration as historical site the alleged burial ground of Apo Mamalu in sitio Mikasili, Tangkulan, Damulog town. Apo Mamalu and his brother Apo Tabunaway are believed to be forefathers of the Mindanao lumads.

"*I'm not here to side with the dam project, but I am speaking out because I think it is premature to declare it as historical site because of the absence of scientific evidence to prove the claim," Burton said. Burton is the curator of the Museo de Oro in Xavier University*.

During the general assembly of the Mindanao Association of Museums at the Bukidnon State University last Nov. 11, Sen. Juan Miguel Zubiri, who was the guest speaker, announced that the Apo Mamalu burial site will be declared as historical site, making it a prized cultural heritage treasure of the country.

"*In issues like this, archaeological evidence is needed, and so far we have none*," Burton stressed.

Roldan Babelon, of Natabuk or Cultural Solidarity of Indigenous Peoples in Bukidnon, however, said that it is against the beliefs of the lumads to excavate burial sites.

Elders of the Manobo tribe, however, said that an exception can be made *"just to protect Manobo culture and resolve the issue. "It is true that it is against our culture to excavate the burial site, but there are ways to get the permission of our ancestors, like performing a ritual, just we could resolve the issue,"* said Datu Pendulanon (a.k.a. Rogelio Lahunay), tribal chieftain of Kibawe town in Bukidnon.

An angry tribal chieftain of the Municipality of Damulog also in Bukidnon lambasted a non-government organization for allegedly disrespecting the Manobo tribe and damaging their culture. Datu Feliciano Angaan, said: "*They don't have respect for us. Last Sunday, they, along with the personnel of the National Musuem, went to the burial site to do a ritual without even bothering to ask our permission."*

According to the lumad leaders, it was not Apo Mamalu who ventured north of the Pulangi River, but his brother Apo Tabunaway. Apo Mamalu, according to them, stayed in the mouth of Pulangi River (Rio Grande de Mindanao) in Cotabato to be with his sister Bae Putri who married the first Muslim scholar to reach mainland Mindanao, Shariff Kabunsuan. Apo Mamalu, according to this narrative, converted to Islam and Apo Tabunawan went upstream (north) of the Pulangi as he refused to convert to Islam.

2.4.8.4.5 Ethnography - Religion

Manobos are traditionally animistic. They recognize and pay respect to a pantheon of spirit deities which are patrons of the elements and processes of nature. There are about fifty spirit deities, of which the most important are Ibabasuk, the patron of agriculture, and Manawbanaw, the god who dominates a complex interrelated system of taboos." The Manobos recognize a myriad of other spirit beings whose influence controls every aspect of their society. Serious illness is attributed to spirit activity in response to a broken taboo or to the desire of a spirit or the soul of an ancestor to communicate a need to a living person. The society has a group of religious specialists or shamans. The function of a shaman or *baylan* is to communicate with the unseen world by means of a familiar spirit to interpret the message intended through an illness. Animal sacrifice is the usual remedy for serious illness as well as the means for obtaining the favor of the gods or spirits for planting, marriage, a hunting expedition, or similar activities.

A recurrent theme in Manobo religious thought and ceremonies are the legendary happenings which are related in a long epic song called the *ulagingen*. This epic tells of the struggles of an early band of Manebos during an extended period of drought. During their wanderings in search of food the gods pitied them, granted them the gift of immortality, and took them to heaven through a hole in the sky.[9]

2.4.8.4.6 Chance Historical Find During Construction/Operation.

In the event that construction activities would yield accidental discovery of cultural or historical property, the Proponent will coordinate with concerned government agencies (Local Government Units, National Historical Commission of the Philippines and the National Museum), to determine the historical/cultural value of such discoveries. Management of the site where the discoveries were made shall be governed by Item 22, Section 33.1 of the Implementing Rules and Regulations of RA 10066 (National Cultural Heritage Act of 2009) which states that: "*When the presence of any cultural or historical property is discovered, the National Museum or the National Historical Commission of the Philippines which may act through the Commission shall immediately suspend all activities that will affect the site and shall immediately notify the local government unit having jurisdiction of the place where the discovery was made. The local government unit shall promptly adopt measures to protect and safeguard the integrity of the cultural property so discovered and within five (5) days from the discovery shall report the same to the appropriate agency. The suspension of these activities shall be lifted only upon the written authority of the National Museum or the National Historical Commission of the Philippines and only after the systematic recovery of the archaeological materials. Such activities may include agricultural and engineering works, mineral and marine explorations*".

2.4.8.5 Threat to Public Health

During the construction phase, measures should be undertaken to reduce the risk and/or exposure to dust and other diseases related to construction activities.

During construction gas emissions as well as dust from diggings may be experienced by communities near the construction site. Impact to schooling of children may exhibit in potential contraction of illnesses related to construction such as asthma, allergies and other lung diseases which may lead to absences or in extreme cases, drop-outs. Measures to prevent these conditions shall be designed including establishing alternate routes to school facilities, if necessary and involving parents in taking care of the health of their children.

Drowning is also a concern as this may happen during the operation phase. Appropriate signs including prohibition in danger areas must be informed to the community residents. In case of dam water releases during typhoons when dams reach their critical level to overflow must also be coordinated with officials and residents through meetings and warning signals.

Construction accidents from diggings and hauling and transport will also endanger life of workers as well as residents near the construction area. Due to expected increase in income, recreational activities such karaoke bars or drinking alcohol may increase health risks such as STDs and other reproductive health issues. Incidence of gambling may increase due to extra income will further cause potential conflicts in the household. Mitigating measures will have to be planned to prevent potential threats to public health and safety including use of safety gears among workers, installation of appropriate road/construction signs for accident prevention, STD/HIV awareness among workers, and appropriate policy in the worksite, among others.

2.4.8.6 Generation of Local Benefits from the Project

Benefits from the project can be categorized as direct and indirect. Direct benefit would initially cover the increase of avialbale electricity for Mindanao as a result of project implementation. Direct benefits to the locality would the provision of employment, livelihood, scholarships and trainings by the proponents. Other relevant laws and policies e.g., ER 1-94 (DOE) and Community Royalty Development Plan (IPRA) would also provide benefits to the stakeholders.

Indirect benefits include possible increase in income due increase in economic activities during the construction and operation phase of the project is also expected to contribute to the increase in income.

2.4.8.7 Threat to Delivery of Basic Services

For the water needs of the Project during its construction phase, it will source its supply from the local water system. Also, for its other water needs (office, domestic) during the operation phase it will connect with the local water district.

The Project is not expected to compete with the local power supply. The peak of electricity consumption of the Project is during the construction phase. After construction, electricity use of the Project will be limited to office/administrative purposes. The Project will connect to the local grid for its electricity needs and may acquire generators for emergency purposes.

In all Barangay, available communication facilities include television, radio, cell phones, telephones and newspapers. The Project is not expected to compete for the available communication facilities in the area.

The project may pose risks for other basic services that will be affected as a result of construction and operation activities. Roads and creeks that may be temporarily affected will be rehabilitated after construction. As to resources that will be inundated due to dam construction and operations, other resource such as land replacement is expected to generate enough production to restore agricultural losses including potential fishery resources within the dam itself. Improvement of the area as a potential tourist spot may bring informal settlers in the area. Watershed management projects may improve water resources and contribute to sustaining the life of the dam.

2.4.8.8 Traffic Congestion

The Project is expected to affect the traffic situation only during the construction phase. Appropriate signs and measure should be undertaken to minimize potential road accidents during the construction. During the operation phase, the Project is not expected to adversely affect the traffic situation.

3 IMPACTS MANAGEMENT PLAN

Prediction and evaluation of the potential impacts, issues and concerns of the project is based on the impact areas earlier delineated. The cost for the measures identified will be incorporated to the total project cost. Table 3-1 shows the summary of potential impacts and its mitigating measures.

3.1 Pre-Construction Phase

The impacts associated with the pre-construction phase may be insignificant in physical and biological aspects. Pre-construction activities include land survey to determine exact location and alignment of the dam structure and appurtenant facilities. It also includes finalization of plans, including the resettlement action plan for affected stakeholders.

The significant impact includes the apprehension of the locals over their land, crops, and livelihood that might be affected by the proposed project. Among of these are anticipated loss of portions of land and crops due to generation of right of way for the construction of proposed structures. In order to mitigate the apprehension of locals over the project, during the preconstruction phase, information dissemination in the community about the project through coordination with LGU's, PO's, NGO's, barangay officials and other concerned community groups should be conducted. This program will introduce the proposed project in the area and avert negative perception of people towards the project. It will also serve as an initial step in the formulation of Information, Education, and Campaign (IEC) Plan.

Inventory and assessment of land, crops and improvements that will be affected by the project should be undertaken prior to project construction. Land Acquisition and Resettlement Plan (LARP) must be finalized for the equitable compensation and acquisition scheme of affected families and properties. Furthermore, in case that this project will have an adverse impact on the socio-economic of the affected families, provision of alternative livelihood during the restoration may be considered.

To ensure timely availability of required resources and compliance with the compensation issues, compensation costs should be included in the project cost. Though, in some instances not all of this land may need to be compensated, the beneficiaries may opt to donate in exchange of conditions that they will be prioritized for hiring during construction.

Also, prior to project construction, the proponent must coordinate with the DENR to seek clearance for the identification of required documents for the issuance of needed tree cutting permit (PD 705). To compensate the vegetation to be lost, the proponent should replace the number of trees removed/cut and plant them to nearby areas or in accordance with the advice of the DENR.

3.2 Construction Phase

3.2.1 Loss of Vegetation and Habitat

The project will require land clearing to give way for the construction of the dam, powerhouse, access roads and reservoir. This entails the removal of plant species that may affect flora and fauna diversity composition of the watershed, and portions of the service areas. This removal of vegetation may also remove habitat and cause temporary disturbance for fauna assemblages, decreasing areas for food sources, territories and breeding grounds. It also exposes soil surface to rainfall and induces surface run-off. This in turn may increase soil erosion, sedimentation and siltation of the Pulangi River and other bodies of water within the proposed Project Area.

As per DENR Memorandum Order no. 05 of 2012 mandated that "Uniform replacement ratio for cut or relocated trees" item 2.2 "For planted trees in private land and forest lands... tree replacement shall

be 1:50 while naturally growing trees on the same area, including those affected by the project shall be 1:100 ratio in support of the National Greening Program (NGP) and Climate Change Initiatives of the Government".

As such, nurseries may be established to provide planting materials for such planting. It is recommended that globally threatened, indigenous and endemic species be planted, instead of exotic species, for the recovery of denuded lands. This promotes survival and conservation of local species while providing soil cover, therefore mitigating vegetation loss, habitat loss, soil erosion, sedimentation and siltation of water bodies.

3.2.2 Accelerated Soil Erosion and Siltation

Soil erosion will happen during construction due to slope and geological conditions in the watershed area and service areas. Further, the removal of the vegetation and excavation of soil to give way on the construction of dams, reservoir, powerhouse and access roads will generate soil erosion and will increase the sedimentation and siltation of the downstream river system. During construction the disturbed area will be the source of sediment, as construction will need to be undertaken within the channel bed.

Development of erosion control plan that will involve proper timing of construction activities, site protection, proper disposal of excavated materials and rehabilitation measures that address soil erosion resulting from construction as well as good operating procedures may be adopted by the contractor. Also, sediments must be contained within the construction site through sediment basins or other retention structures such as rock dikes, silt fences, siltation ponds and other measures.

These may be stipulated in the contract as well as the conditions that will ensure environmental integrity during construction and this will also become the contractor's and proponent's responsibility.

3.2.3 Change in Landform and Topography

The construction of dam would variably change the topography and surrounding landscape. With the construction of the dam, inundation of lands for the reservoir, and construction of the powerhouse are among the related activities that may alter the form and topography. Likewise, construction of camps/ bunk houses and equipment stock yard, temporary dumpsite of waste materials and spoils may cause moderate changes in the areas landscape.

Confined clearing and construction activities only to areas covered by the dam sites, access roads, powerhouse and reservoir area should be conducted. Reforestation to immediate vicinity of the project area may be implemented. Likewise, the contractor may undergo proper clean up and abandonment of the site after completion of the project, such as removal of bunkhouses, stock yard and other unwanted structures.

3.2.4 Contamination of Water Bodies

During construction, heavy equipment will need fuel and lubricants for proper functioning. Waste from machineries such as oil and grease products may find their way to the rivers and ground water if not handled properly. These may pollute the rivers, block off photosynthesis and other plant processes, and may eventually affect the aquatic environment and organisms. This may affect river fish resources, source of domestic and potable water of downstream communities and possibly the aqua-culture sites.

Spills of oil and greases in the equipment maintenance area must be avoided through proper housekeeping, regular inspection of working areas, proper maintenance and provision of waste

containment area for filters and other consumables. Also, contractors should ensure that fuel and oil storage areas should be located 20 meters away from any watercourses and provided with inceptor traps so that accidental spills do not contaminate the site. Contained waste and used engine oils must be subjected for recycling by giving it to the Certified Collection Centers (CCC) nearest to the project area.

3.2.5 Noise Pollution

During construction, land-clearing, hauling of materials and spoils in and out the project area and other activities would undoubtedly generate noise in the host communities. Impacts are generally on the households near the construction site and communities along the main access road and powerhouse where construction and waste materials will be transported. The noise generators will be the heavy equipment's, such as bulldozers, pay loaders, rollers, dump trucks and other machineries.

To mitigate noise pollution during the construction, it is recommended that contractors may use properly maintained heavy equipments fitted with appropriate mufflers or silencers. Likewise, work schedule may be limited during daytime to avoid disturbance in the surrounding/nearest community. Operators must be properly oriented in the use of the machines and heavy equipment, avoid excessive pumping on the fuel and use of horn. Warning signs and speed limits in populated areas may be established.

3.2.6 Dust Generation

During construction, excavation of soil and transport of materials are perceived to generate dust. Significant impacts are more likely on the communities along the route where materials will be hauled and transported. Activities such as clearing, hauling and stock piling of earth materials may raise the concentration of dust in the construction site. However, this condition is temporary during the land clearing and construction phase.

To mitigate the impacts on dust generation during construction phase, contractors should ensure that access roads and other dust generating areas would be frequently sprayed two (2) to three (3) times a week with water using water truck/s. It is also important to always observe speed limit of vehicles in dusty roads especially near to populated areas.

3.2.7 Increased Solid and Liquid Wastes

Project workers will be brought to the project area. Temporary camps, motor pool, guard house and other important facility/ies will be put in place near the construction areas. Hence, this could generate industrial and domestic wastes such as engine parts, tires, garbage, sewage and even human waste and other more.

The contractor and proponent should implement proper waste management. Installation of Material Recovery Facility (MRF) for waste segregation and compost pits may be provided in the construction and workers campsite/bunkhouses.

Waste storage facilities such as septic tanks or portable toilets may be installed on site during construction. The contractor should ensure that no untreated human wastes should be allowed to enter any water course where this will affect downstream water quality, aquatic environment, and human health. Change in aesthetic character of the area can be minimized by disposing of excavated materials as soon as possible to designated temporary dump sites. Likewise, the contractor must undergo proper clean up and abandonment of the site such as removal of temporary bunkhouses, stock yard and other unnecessary structures after completion of the construction activities.

3.2.8 Increase in Traffic

Due to the entry and exit of heavy equipment, hauling trucks and office vehicles, traffic may increase in the affected municipalities. To mitigate the impacts of increased traffic, road signs may be established to inform stakeholders of the incoming and outgoing traffic. Setting up of routes towards construction sites may be implemented so as not to further increase traffic at main roads.

3.2.9 In-migration and Employment

During construction, influx of workers together with their families may be expected. These would create strain and stresses, competition and demand for local resources. The impacts of the influx of workers are expected to occur near the dam site and in significant settlement areas. Hence, increase of population into the watershed is also expected. More so, with the inundation of the reservoir affected families are expected to move upslope of the watershed if they will not be relocated outside which will result to further denudation of the current environment of the watershed.

During construction qualified residents of host communities must be given priority in hiring. This must be coordinated with the LGU's and Barangay officials to enhance community appreciation of the project and will provide employment and income to the residents especially to those affected families.

3.2.10 Aquatic Habitat Fragmentation and Productivity

Siltation has a profound impact on freshwater biota in that it hinders respiratory efficiency in aquatic organisms (macro-invertebrates and vertebrates, including larval amphibians). The amount of silt reaching the river would in part be dependent on the distance between the construction site and the nearest overflow entry into Pulangui, especially during the rainy season. Localized site disturbance may be expected to be caused minimal effect on Pulangui and also only for a limited time, when the amount of silt and other soil materials from erosion upstream combined. Loss of productivity as a may also be minimal, as rivers in general are known to be less productive than standing waters like lakes and impoundments. On a theoretically positive note, silt from construction activities in the more upstream portions of project would contribute towards a more mineral rich soil in the floodplain, thus increasing agricultural productivity. How much increased in productivity would it cause may also be minimal, as compared to the yearly seasonal input of minerals from non-project-related erosion that occurs upstream especially during the rainy season.

Such a change may lead to a drastic change in the taxa composition and structure of the impact area (Reynolds et al 1994).. As to primary productivity, a lentic environment would be conducive to the growth of phytoplankton in general. Thus, it is predicted that phytoplankton density would increase. An increase in species richness would depend on the rate of colonization by species not observed now due to depressed densities or due to non-successful establishment. An increase in primary productivity would probably also lead to an increase in secondary productivity. The effect of a lentic environment on aquatic macro-invertebrates may be equivocal. On one hand, the increase depth reduces the favorable substratum for aquatic insect larva to only the banks of the impounded dam waters. The steep banks usually are unstable and do not have the hard surfaces of a stony river bottom. The same shift in composition of molluscs may be expected. The river molluscs are dominated by running water tolerant species like the thiarids and melanid. In the lake environment, though these species could still thrive, molluscs that thrive well in standing waters, like pilids, planorbids and lymnaeids, may increase in number. Shrimps may also increase in number but could be found in the banks. As to fishes, we may expect an general increase in fish number and diversity. As has been observed in Pulangi lake, dams changes the river typology from a running water environment to a standing water environment, and this may be favorable to a lot of fishes especially those that are considered as a valuable fishery resource – e.g., the introduced tilapia and carps - but

maybe detrimental to the running water species like the benthic gobies and the migratory species like eels.

3.3 Operation Phase

3.3.1 Changes in Water Quality

Decomposition of the inundated vegetation may alter the chemical composition of the water in the reservoir. Greenhouse gas emissions are expected since decomposing vegetation by bacteria will release methane and carbon dioxide. These gases may escape from the reservoir and contribute to the green house gases in the atmosphere and further incite climate change. In addition, the establishment of fish cages on the reservoir may increase the nutrient loads in the reservoir due to introduction of feeds and excrements from the fishes which may change water quality.

It is recommended that vegetation clearing be conducted before establishment of the reservoir to mitigate the effects of climate change. Proper monitoring of the water quality may be implemented to determine the changes in water quality that may occur over time. This will prepare farmers and other stakeholders of the changes which may be important in their fertilizer application.

3.3.2 Structural Failure or Dam Break

Dam structure break is a potential threat with adverse impact on extreme case, though occurrence may be rare, if it happens, it may be characterized as a force majeure. Structural failure or dam break is likely to flood the downstream low lying communities.

The dam structure will be designed to conform to the acceptable design standards to assure the integrity of the structure and the appurtenant structures. This should include among others strict monitoring during construction and operations, adherence to acceptable engineering standards for structure construction. The un-gated ogee type spillway is part of the facility that will allow excess water to flow in the event of high and intense rainfall. Nevertheless, dam structure break warning and evacuation plan should be prepared in cooperation with the LGU.

The Proponent shall prepare the environmental compliance specifications for the tendering process. This includes the formulation of the Contractor Environmental Management Plan (CEMP), a section that the Contractor will be required to address at the time of bidding that outlines how the Contractor's company will address the environmental compliance requirements together with an itemized cost breakdown of the mitigation measures.

Table 3-1: Environmental Management Plan

Project Phase / Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention for Mitigation or Enhancement	Responsible Entity	Cost	Guarantee / Financial Arrangement
I. PRE-CONSTRUCTION PHASE						
1. Acquisition of Right of Way	Land/ People	Loss of land and crops ownership Damage to Properties	- avert negative perception of people through IEC - Land Acquisition and Resettlement Plan (LARP) must be finalized for equitable compensation and acquisition scheme of affected families and properties	PHPC-Environment Unit/PCO Community Relations	Included in LARP cost	Included in LARP Budget
II. CONSTRUCTION PHASE						
1. Site Preparation -Vegetation Clearing, Grubbing, and stripping	Terrestrial Ecology/ Biota and Riparian Zone	- Vegetation loss - Removal of economically and ecologically important species - Habitat fragmentation	- Avoid unnecessary cutting of vegetation - Inventory of biota and riparian zone as basis for species and volume replacement - Compensate through planting indigenous tree species suitable in the area - Implement Watershed Management Plan	PHPC-Environment Unit/PCO	Php 1,500,000.00	IWMP
2. Earthworks (Soil excavation; stockpiling; hauling of raw materials to construction site; Grading and road construction)	Slope and Topography	- change in topography - increased landslides	- use contour- trenching, furrowing, terracing, ripraps and vegetative measures - Limit construction activities during dry season -adequate positioning of stockpile areas away from river/creek. - road-bank soil erosion prevention/minimization (use of biological or non-biological structures)	PHPC-Environment Unit/PCO	Php 10,000,000.00	Included in Construction Budget
	Soil/ Pedology	- increased soil erosion				
	Aquatic Flora and Fauna Biota and Riparian Area	Destruction or disturbance of aquatic life due to works in rivers. Degradation of aquatic habitat, species decline Increased erodibility of the riparian area.				
	Hydrology	Change in river depth and width				
	Water Quality	Change in physico-chemical characteristics of the river. (TSS, TDS, Oil and Grease, and Heavy Metals)	- minimize area of earth moving and efficient collection of excess earth materials	PHPC-Environment Unit/PCO	Php 1,500,000.00	Included in Construction Budget Included in Construction Budget

Project Phase / Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention for Mitigation or Enhancement	Responsible Entity	Cost	Guarantee / Financial Arrangement
	Air	Increase in Total Suspended Particulate (TSP) within and around the Project site.	Regular sprinkling of water along the access road during dry season, Impose speed limits in construction area. maintenance of construction equipment use of good quality fuel to reduce SO_x and NO_x emissions	PHPC-Environment Unit/PCO		
	Noise	Noise pollution	Use of mufflers and exhaust silencers Periodic inspection and maintenance of equipment Construction works should be done during daytime only			
3. Use of Vehicles and Heavy Equipment	Water Quality	Oil and grease leaks from heavy equipment and vehicles	Periodic inspection and maintenance of equipment	PHPC-Environment Unit/PCO		
	Air Quality	Increase in SO_x and NO_x concentrations from vehicle emission	- designation of motor pool with complete facilities -equipment should always be in good running condition	PHPC-Environment Unit/PCO		
4. Construction of Structures	Hydrology	Change in river depth and width Change in river flow Increased Siltation and Sedimentation	- provision of diversion structures to prevent blockage of river flow	PHPC-Environment Unit/PCO		
	Freshwater Ecology/ Riparian Zone	Change in Species richness due to decrease water flow Reduction in river width leading to increased width of the riparian area. Development of “pools” that				

Project Phase / Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention for Mitigation or Enhancement	Responsible Entity	Cost	Guarantee / Financial Arrangement
		could encourage plankton growth but lessen the habitat for migrating species.				
	People	Employment Opportunities	Priority of hiring of qualified laborer are given to the residents in the area	PHPC-Community Relations	Php 500,000.00	Part of Social Development Program/MOA with Stakeholders
		Temporary increase of illness to workers due to increase of Pollutants.	Provision of temporary housing and sanitary facilities such as temporary septic tanks. Proper orientation of workers on waste management and disposal	PHPC-Community Relations	Php 1,000,000.00	
		Accidents to workers and exposure to occupational hazards	Hiring of physically fit workers Provisions of protective and safety gears to workers Provisions of emergency medical facilities	PHPC-Community Relations	Php 1,000,000.00	
		Increased income and business opportunities	Prioritization of local supplier or service provider	PHPC-Community Relations	Php 200,000.00	
		Increase in traffic volume due to entry and exit of vehicles, trucks, and heavy equipment.	Re-routing of traffic near construction sites. Put up signages indicating passage of trucks and heavy equipment. Coordinate with LGUs	PHPC-Community Relations	Php 300,000.00	
		Temporary disruption of income sources/ livelihood for those who will be displaced/ relocated	Provision of livelihood training, livelihood assistance and subsistence allowance for displaced families	PHPC-Community Relations	Php 1,500,000.00	
		Permanent and temporary dislocation of households and loss/destruction of properties, trees, and crops.	Implementation of mutually acceptable compensation scheme Implementation of an IEC program	PHPC-Community Relations	Php 2,500,000.00	
		Temporary disruption of access	Ensure provision of institutional facilities	PHPC-Community	Part of LARP cost	

Project Phase / Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention for Mitigation or Enhancement	Responsible Entity	Cost	Guarantee / Financial Arrangement
		to institutional and basic services for those who will be displaced/ relocated	(health center, barangay hall, school, churches) at relocation site	Relations		
Excavation	Riparian channel	Temporary to permanent physical alteration of site where construction work is to be done dam	Minimize disturbances and proper disposal of spoils	PHPC-Environment Unit/PCO	Php 2,000,000.00	Included in Construction Budget
	Aquatic flora and fauna	Reduced biodiversity because of direct habitat alteration or effect of siltation and secondary disturbances; Reduced productivity and upstream-downstream transit of organism in the vicinity of construction area.	Minimize direct disturbance, even allowing a portion of the river to be open for organism transit; minimize all forms of direct and indirect waste discharge to the river water. Compensation from lost and reduction of productivity of harvested aquatic organisms may be in order.	PHPC-Environment Unit/PCO	Php 1,000,000.00	
III. OPERATION PHASE						
1. Dam Operation and Maintenance/ water distribution	Geology	Prevent/control flooding	Adequate release of water during heavy rainfall Implementation of emergency response plans and safety procedures	PHPC-Environment Unit/PCO	Php 1, 200,000.00	Included in Construction Budget
	Slope and Topography	Increase in landslides in reservoir area				
	Terrestrial Ecology	Improvement of the sub-catchment of River	Implementation of Watershed Management Program through community based approaches under multiple-use concept. Local institutions to be given a role in program implementation.			
	Hydrology	Siltation resulting to loss of reservoir storage and usable life	Institute a reservoir sediment monitoring, management and control			
	Water Quality	Change in water quality due to feeds and excrements in Aqua culture	Minimize nutrient loading by following feeding schedules in aquaculture Monitor water quality in reservoir.			
	People	Employment opportunities	Prioritization of host communities in employment	PHPC Communit Relations	Php 500,000.00	Part of Social Development Program/MOA with Stakeholders

Project Phase / Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention for Mitigation or Enhancement	Responsible Entity	Cost	Guarantee / Financial Arrangement
		Increased source of livelihood for locals	Assistance to LGUs in formulation and implementation of alternative sources of livelihood			
Host communities	People	Monetary and non-monetary benefits to host communities Increase in access/mobility of goods and services Possible creation of recreational area/ park near the dam site Accidental drowning Increased risky behaviors as a result of increase in income	Proper utilization of resources. Conduct IEC Program Proponent to allow residents to use access roads The Proponent can utilize portion of the area near the dam site and transform it to an activity park / recreational area. Formulate agreements to displaced/affected settlers Ensure proper signages Conduct IEC Program; conduct financial literacy programs	PHPC Community Relations	Php 2,000,000.00	Part of Social Development Program/MOA with Stakeholders
2. Generation of Solid waste	Water Quality	Change in water quality due to improper waste disposal	Implementation of solid waste management including provision of waste bins. Disposal thru DENR accredited third party service provider	PHPC-Environment Unit/PCO	Php 1,000,000.00	Included in Construction Budget
		Change in water quality (Oil and Grease) due to improper waste disposal	Periodic maintenance of vehicles	PHPC-Environment Unit/PCO	Php 500,000.00	
3. Use of vehicles for mobility i maintenance and operations	Air Quality	Change in TSP, SO_x, and NO_x levels in air				

Project Phase / Environmental Aspect	Environmental Component Likely to be Affected	Potential Impact	Options for Prevention for Mitigation or Enhancement	Responsible Entity	Cost	Guarantee / Financial Arrangement
IV. Project Abandonment						
Dismantling/ removal of facilities such as camps, storage yards, workshop areas and motor pool	Land and water quality	Land and water pollution	Allocate certain percentage of the construction cost for clean-up after construction - salvage materials that are usable which can be used by the local workers or residence	PHPC-Environment Unit/PCO	Php 1,000,000.00	Part of Decommission and Rehabilitation Cost
	Terrestrial Ecology	Loss of species richness	- Continual rehabilitation and re-vegetation of idle and barren lands using indigenous species.	PHPC-Environment Unit/PCO	Php 1,500,000.00	
	Riparian flora and fauna	Riverbanks stabilization through engineering measures and/or regreening technologies	Community-based regreening and maintenance could be instituted	PHPC-Environment Unit/PCO	Php 1,500,000.00	
	Aquatic flora and fauna	Allow enough time for organisms to repopulate the altered environment	Compensation or provision of alternative source of income could be provided.	PHPCCommunity Relations	Php 2,000,000.00	
Should the Project be abandoned or decommissioned after its economic life, the proponent will provide DENR with the abandonment/decommissioning plan, two (2) years before its actual date of abandonment/decommissioning.						

4 ENVIRONMENTAL RISK ASSESSMENT

4.1 Natural Hazards Assessment

4.1.1 Seismic Hazards

Potential seismic/fault-related hazards that could impact the project include ground acceleration, ground rupture, liquefaction and liquefaction-induced lateral spread, seiche and landslides. Landslides are discussed under mass movement hazards. Reservoir-triggered seismicity, although not considered as a natural hazard but as a potential hazard, is included.

4.1.1.1 Ground Acceleration

Intense ground shaking could cause structural distortions in dams, appurtenant structures and equipment, and their foundations. In general, the intensity of ground shaking is magnitude-dependent, and gradually decreases with distance from the source. Difference in ground conditions, however, may cause deviations from this expected norm particularly in areas underlain by recent alluvium.

Earthquake Generators

The International Commission on Large Dams (ICOLD, 2010a) guidelines require that all potential earthquake generators within a radius of 100 km of a proposed project site be considered in the design of the project. The distance may be increased depending on the importance of the project or of the earthquake generator. The earthquake generators considered are the Cotabato Trench, Mindanao Fault (Daguma Extension), Davao River Fault and the Agusan Marsh fault segment of the Philippine Fault (See **Figure 2-4**).

Peak Ground Acceleration

Peak ground acceleration (PGA) is determined either by probabilistic or by deterministic approach.

In the 2017 Philippine Earthquake Model (PEM), PHIVOLCS performed a probabilistic seismic hazard analysis (PSHA) of the Philippines and Metro Manila. The PSHA calculated PGA and spectral acceleration (SA) contour maps for the following ground conditions based on soil profile type and average shear wave velocity of the upper 30 meters of the soil layer (Vs30) as classified by the Association of Structural Engineers of the Philippines, Inc. (ASEP) under the 2015 National Structural Code of the Philippines (NSCP):

Rock site	:	Soil Profile Type S_C[3] ; Vs30 = 760 m/sec.
Stiff soil	:	Soil Profile Type S_D[4]; Vs30 = 360 m/sec.

Calculated PGA response for rock site, and SA responses for rock site and stiff soil at the project area for a 500-year return period (10% probability of exceedance in 50 years) are shown below (**Table 4-1**).

[3] NSCP describes S_C soil profile as Very Dense Soil and Soft Rock.
[4] NSCP describes S_D soil profile as Stiff Soil profile.

Table 4-1: Peak Ground Acceleration and Spectral Acceleration Responses (g) at the Project Area for 500-year Return Period

(Source: PHIVOLCS, PEM, 2017)

Ground Condition	PGA	SA (0.2sec)	SA (0.5sec)	SA (0.8sec)
Rock site	0.3	-	-	-
Stiff soil	0.3	1.0	1.0	0.8

The seismic zonation map in the 2015 NSCP defines the project area to be within Zone 4 which has an assigned PGA of 0.4g for Class B rock condition (i.e. rock with shear wave velocity from 760 to 1500 meters per second).

A deterministic approach for estimating peak horizontal ground acceleration using the attenuation relation was formulated by Fukushima and Tanaka (1990). The attenuation relation is given by the equation:

$$Log10A = 0.41M – log10(R + 0.032*100.41M) – 0.0034 R + 1.30$$

where A is the mean of the peak acceleration from two horizontal components at each site (cm/sec^2), R is the shortest distance between the site and fault rupture (km), and M the surface-wave magnitude. Mean rations (coefficient) according to the nature of the subsurface are then applied to the derived A-value.

Table 4-2 shows the calculated PGA assuming different earthquake scenarios from different possible earthquake sources. Applying the attenuation relation equation developed by Fukushima and Tanaka, the computed PGA of a major seismic event from the earthquake generators could range from 0.03g to 0.18g.

Table 4-2: Calculated Peak Ground Acceleration Values (Fukushima and Tanaka, 1990)

Possible Earthquake Source	Possible Earthquake Magnitude	Approx. Nearest Distance (km)	Calculated PGA (g) values	
			Rock	Medium Soil
Davao River Fault	7.0	40.9 [(a)]	0.10	0.18
Mindanao Fault (Daguma Extension)	7.5	92	0.05	0.10
Philippine Fault (Agusan Marsh segment)	7.5	97	0.05	0.09
Cotabato Trench	7.9	160	0.03	0.05

(a) Based on PHIVOLCS *FaultFinder*

Acceptable Risk Level

The acceptable level of seismic risk for design of major structures such as dams is usually prescribed by regulatory agencies or is the responsibility of the owner. Acceptable levels of risk

are usually prescribed based on the consequences of failure or damage to the facility. Strong ground shaking from earthquakes occurring in moderate to close proximity to the project site could result in damage to the proposed dams depending on the earthquakes magnitude, peak ground acceleration, duration of strong shaking and predominant periods. Seismic design criteria for any proposed facility should consider both its operational life and post-closure conditions. The main concern from both a static and a seismic stability point of view is related to excessive movement or slumping of the upstream and downstream slopes of the dam that could potentially compromise its integrity.

Site specific ground conditions and PGA should be given attention in the final design of the infrastructures and facilities. Seismic loading analysis should consider the Maximum Credible Earthquake (MCE) and the Operational Basis Earthquake (OBE).

At a minimum, ground shaking hazard can be mitigated by following the provisions of the NSCP and the National Building Code.

4.1.1.2 Ground Rupture

Ground or surface rupture occurs when movement on a fault breaks through to the surface. Rupture may occur suddenly during an earthquake or slowly in the form of fault creep. Fault rupture almost always follows pre-existing faults. The length of ground rupture and the width of the zone of deformation generally increase with the magnitude and type of earthquake. A ground rupture is rarely confined to a simple narrow and distinct line and the zone of deformation could be as wide as 100 m (PHIVOLCS). Any structure built across faults especially active ones is at risk as the two sides of the fault slip past each other. PHIVOLCS, as a matter of policy, recommends at least a 5-meter buffer zone on both sides of the identified or inferred fault of active lineament.

Based on PHIVOLCS' FaultFinder, a web-based application capable to do proximity searches to active faults, the nearest active fault is the Davao River Fault that is situated some 40.9 km to the northeast of the proposed dam site. The newly-discovered fault line which generated the September 24, 2017 earthquake with epicenter at Wao, Lanao del Sur is some 35 km to the northwest. It is therefore unlikely that ground rupturing from these identified active faults will affect the project site.

4.1.1.3 Liquefaction and Liquefaction-Induced Lateral Spreading

Liquefaction refers to the process whereby water-saturated, cohesionless soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking causing it to behave like a liquid. Liquefaction-induced lateral spreading occurs on mild slopes of less of 0.3- 5% underlain by loose sands and a shallow water table (Bartlett and Youd, 1992 in Rauch, 1997).

Torres et. al., (in PHIVOLCS, 2001) cited at least three sedimentary environments favorable for liquefaction to take place. These are (i) deltaic, (ii) alluvial plain, and (iii) sandspit environment. These conclusions were derived from historical records of liquefaction including the 1990 earthquake wherein liquefaction occurred in Dagupan City. The main determinants that influence an area's susceptibility to liquefaction are mainly (i) grain size, (ii) depth of water table, and (iii) thickness of the deposit. It was found that in all cases, the soils were composed mainly of fine to coarse sand with some clay component. Where the clay content of the soil was in significant amounts, this was found to inhibit liquefaction. Similarly, the studies revealed that the critical depth of the water table at which liquefaction may reach the surface is 2 to 3 m in areas where the saturated sand layer was 2 m to10 m thick.

Given the geological and morphological environment, liquefaction and liquefaction-induced lateral spreading are unlikely to occur at the project site. The PHIVOLCS map of the Distribution of Active Faults and Liquefaction in Region X indicates the project area is not prone to liquefaction (**Figure 4-1**). However, although liquefaction is unlikely to occur at the project site, this does not preclude the proponent to conduct liquefaction potential assessment of the site since the project will build critical structures.

4.1.1.4 Seiches

Seiches, in the context of this report, are earthquake-induced standing waves in an enclosed or partially enclosed body of water such as, in this case, the reservoir area. Standing waves of sufficient amplitude can induce instability of the dam's upstream face. To protect against wave, a concrete slab will be constructed upstream face of the dam, on the reservoir shore or on the sides of a channel. The effects of seiches are of lesser importance for the earthquake safety of a dam than earthquake ground shaking which is the main hazard (ICOLD, 2010b).

4.1.2 Mass Movement Hazards

Mass movement or mass wasting refers to a broad range of geologic processes involving the transport of soil and rock debris with the spread ranging from fast to barely perceptible. These includes, falls, topples, creep, slides, flows; avalanches; slumps of soil, rocks, sediments, or a mixture of all three. Falls and topples are frequently associated with rock slopes while the latter three are related to soil slopes.

4.1.2.1 Landslide

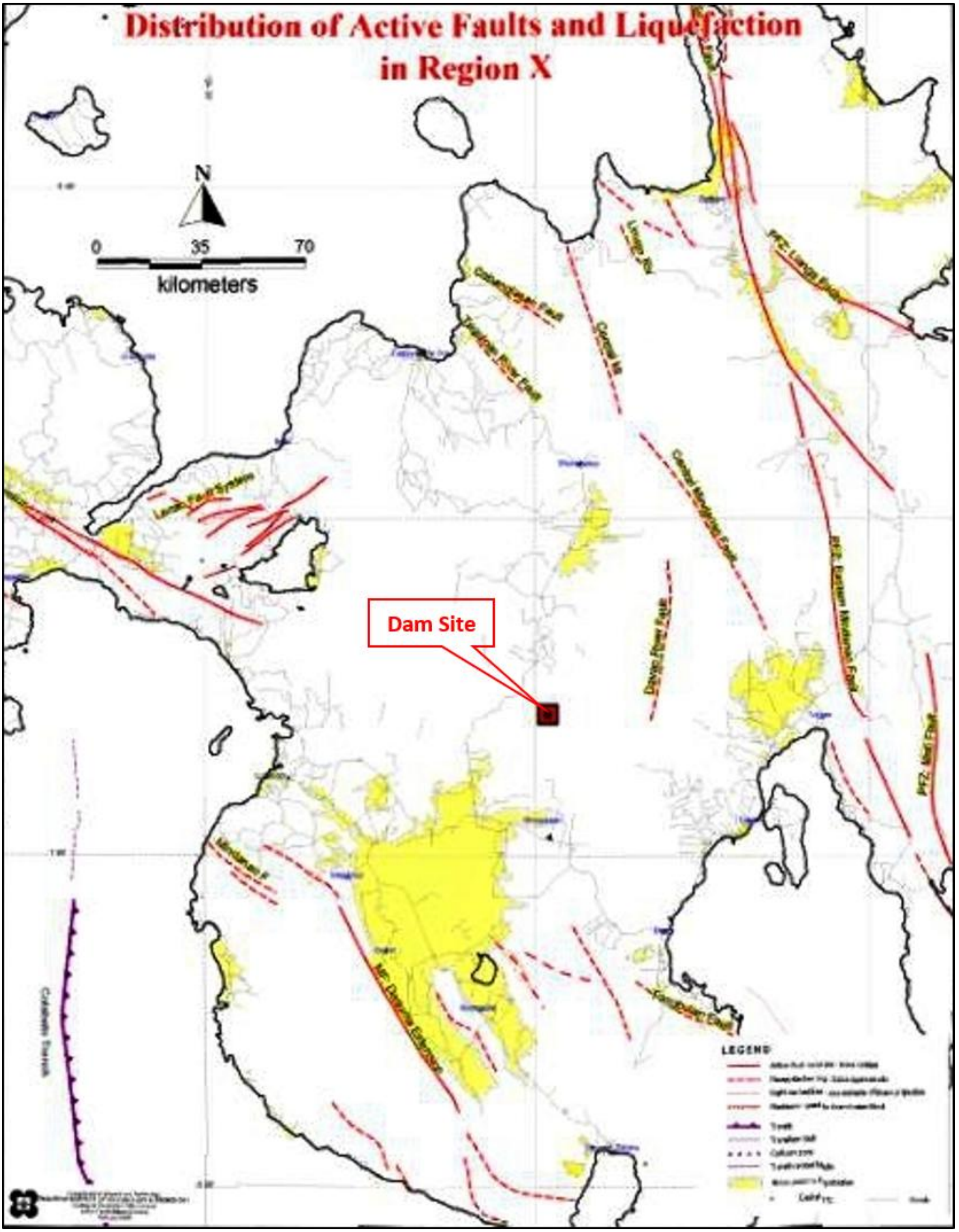
Landslides or slope failure includes any or combination of the following: falls (rock or debris), slides (topple, rotational or planar), flows, creep, solifluction and complex. Slope failure which produces mass movements is caused by several factors relating to the physical properties of the material and the subsequent history of crustal movements, erosion, and weathering processes. Some factors that lead to slope instability are:

- Removal of lateral or underlying support
- Lateral pressure
- Inherent weak material
- Planar features such as faults, joints, bedding planes, foliation, cleavage
- Orientation of slope
- Amount of weathering
- Changes in intergranular forces

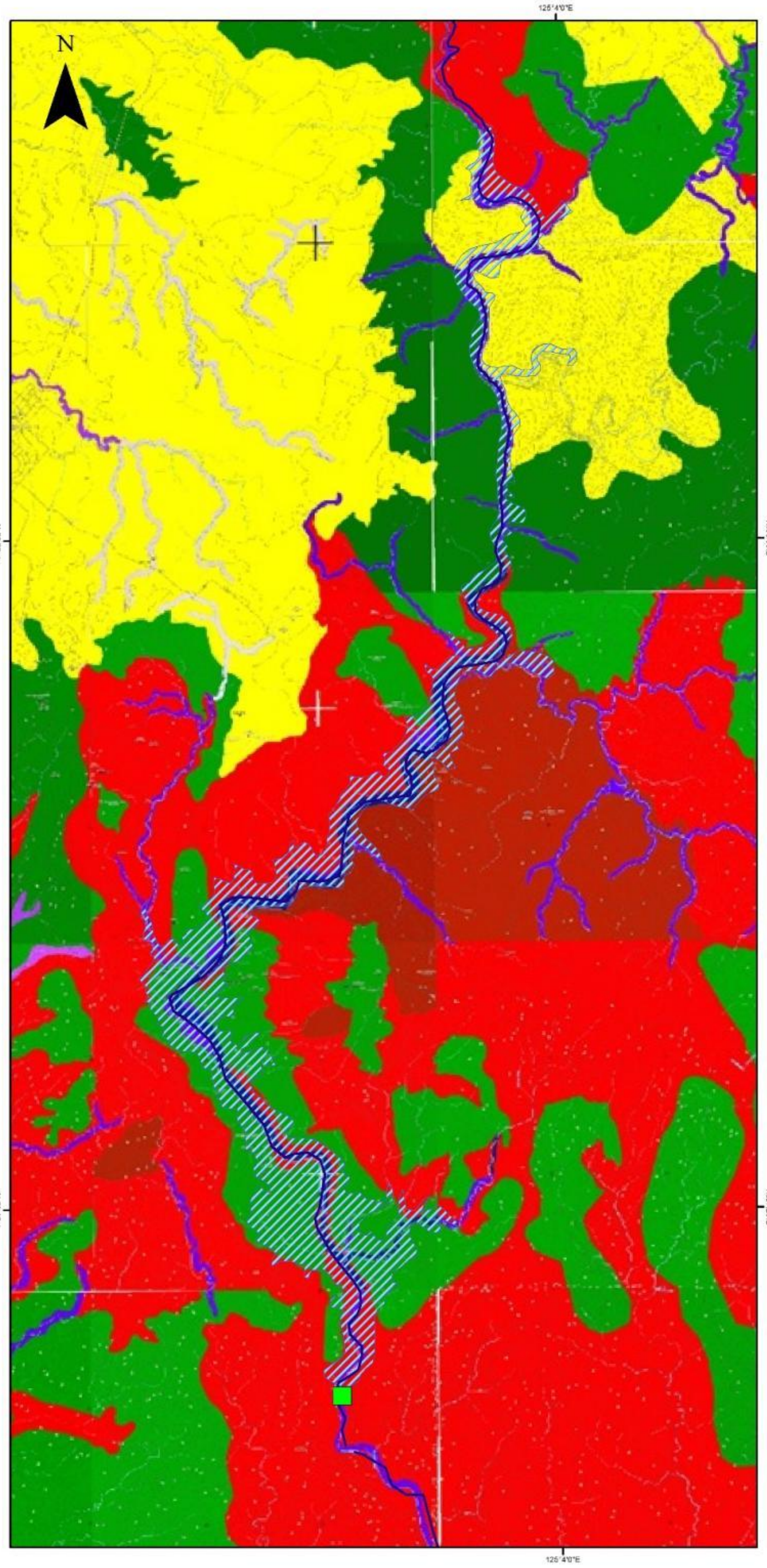
Figure 4-2 is the MGB detailed landslide and flood hazard map showing the proposed dam and reservoir area. The MGB classification ratings of landslide susceptibilities are the following:

Very High:	Areas usually with steep to very steep slopes underlain by weak materials. Recent landslides, escarpments and tension cracks are present. Human initiated effects could be an aggravating factor
High:	Areas usually with steep to very steep slopes underlain by weak materials. Areas with numerous old/inactive landslides
Moderate:	Areas with moderate steep slopes. Soil creep and other indications of possible landslide occurrence are present
Low:	Gently sloping areas with no identified landslide

Distribution of Active Faults and Liquefaction in Region X



Lichel Technologies, Inc. 1403 Prestige Tower Condominium, F. Ortigas, Jr. Road, Ortigas Center, Pasig City	FIGURE TITLE: **Liquefaction Prone Areas**	FIGURE NO. **4-1**



1:60,000

0 0.5 1 2 3

Kilometers

Legend

- Dam
- Reservoir
- River

Landslide

Very high landslide susceptibility
Areas usually with steep to very steep slopes and underlain by weak materials. Recent landslides, escarpments and tension cracks are present. Human initiated effects could be an aggravating factor.

High landslide susceptibility
Areas usually with steep to very steep slopes and underlain by weak materials. Areas with numerous old/inactive landslides.

Moderate landslide susceptibility
Areas with moderately steep slopes. Soil creep and other indications of possible landslide occurrence are present.

Low landslide susceptibility
Gently sloping areas with no identified landslide.

Debris flow / Possible accumulation zone
Areas that could be affected by landslide debris.

Flood

Very high flood susceptibility
Areas likely to experience flood heights of greater than 2 meters and/or flood duration of more than 3 days. These areas are immediately flooded during heavy rains of several hours; include landforms of topographic lows such as active river channels, abandoned river channels and area along river banks; also prone to flashfloods.

High flood susceptibility
Areas likely to experience flood heights of greater than 1 up to 2 meters and/or flood duration of more than 3 days. These areas are immediately flooded during heavy rains of several hours; include landforms of topographic lows such as active river channels, abandoned river channels and area along river banks; also prone to flashfloods.

Moderate flood susceptibility
Areas likely to experience flood heights of greater than 0.5m up to 1 meter and/or flood duration of 1 to 3 days. These areas are subject to widespread inundation during prolonged and extensive heavy rainfall or extreme weather condition. Fluvial terraces, alluvial fans, and infilled valleys are areas moderately subjected to flooding.

Low flood susceptibility
Areas likely to experience flood heights of 0.5 meter or less and/or flood duration of less than 1 day. These areas include low hills and gentle slopes. They also have sparse to moderate drainage density.

Source: Mines and Geosciences Bureau
1:10000 Detailed Landslide and
Flood Hazard Maps

Coordinate System: PRS 1992 Philippines Zone IV
Projection: Transverse Mercator
Datum: Philippine Reference System 1992

Author: Lichel Technologies, Inc.

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FIGURE TITLE:

Landslide and Flood Hazard Map

FIGURE NO.

4-2

The dam site and power house in the Municipality of Damulog and almost two-thirds of submerged reservoir area in the municipalities of Kibawe and Dancagan have high and moderate susceptibilities to landslides. The remaining upstream portion of the reservoir area in Kitaotao Municipality have moderate to low susceptibilities to landslide that terminates at a gorge at Barangay Kitaihon, Kitaotao, the Pulangi River. Photographs of the general slopes along the Pulangi River reservoir area are shown in Annex 3B.

In the PHIVOLCS Earthquake-Triggered Landslide Susceptibility Map of Region X, the dam site and reservoir (submerged) area are classified as having medium susceptibility to earthquake-induced landslide (**Figure 4-3**). The classification is based on the derived peak ground acceleration values (g) and the Philippine Earthquake Intensity Scale (PEIS).

The potential impacts of earthquake triggered landslides on dams are as follows (ICOLD, 2010):

- Rockfalls and landslides may cause damage to gates, spillway piers (cracks), retaining walls (overturning), surface powerhouses (cracking and puncturing and distortions), electro-mechanical equipment, penstocks, masts of transmission lines, etc.
- Mass movements into the reservoir may cause impulse waves in the reservoir;
- Mass movements blocking rivers and forming landslide dams and lakes whose failure may lead to overtopping of run-of-river power plants or the inundation of powerhouses with equipment, and damage downstream;
- Ground movements and settlements due to liquefaction, densification of soil and rockfill, causing distortions in dams; and
- Abutment movements causing sliding of and distortions in the dam.

Construction of facilities in areas susceptible to mass movements should be avoided. If not, some of the engineering and bio-engineering mitigation measures for mass movement hazards are:

- Flatten the slope angles
- Bench the slopes and provide adequate debris catchment areas at grade
- Surface drainage control designed to keep water from entering the unstable area
- Complete or partial removal of unstable material and re-slope
- Buttress the toe of slopes
- Erosion control (interceptor ditches, horizontal drains, etc.)
- Rock reinforcement such as shotcrete, rock bolts, etc.
- Revegetation

It should be emphasized that mass movement hazard is not merely confined at the dam sites and reservoirs but in entire dam catchment areas. The proponent should identify areas that are prone to massive mass movement and adopt appropriate mitigating measures to minimize this impact.

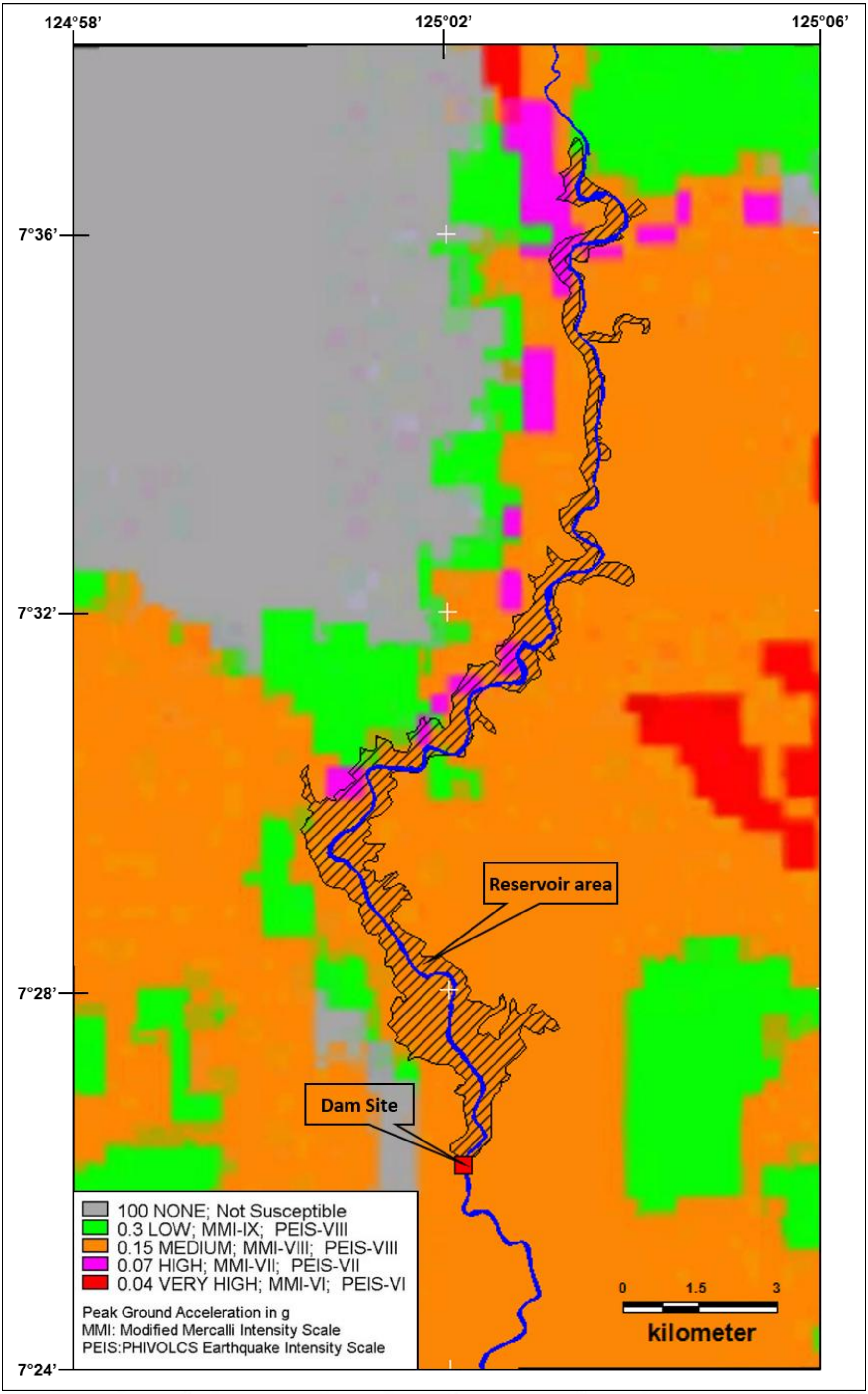

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FIGURE TITLE:

Earthquake-Triggered Landslide Susceptibility Map

FIGURE NO.

4-3

4.1.3 Volcanic Hazards

The degree and extent of vulnerability of an area to volcanic hazards depends on its proximity to an active volcano. Eruption-related hazards include airfall tephra (ashfall), base surge, fissuring and ground subsidence, seiches/tsunami and flooding. The nearest active volcano to the dam site is Musuan Volcano in the municipality of Maramag, Bukidnon Province. The last know activity of Musuan Volcano was reported in 1867 (PHIVOLCS). **Table 4-3** presents the active volcanoes in Mindanao and is depicted in **Figure 4-4.**

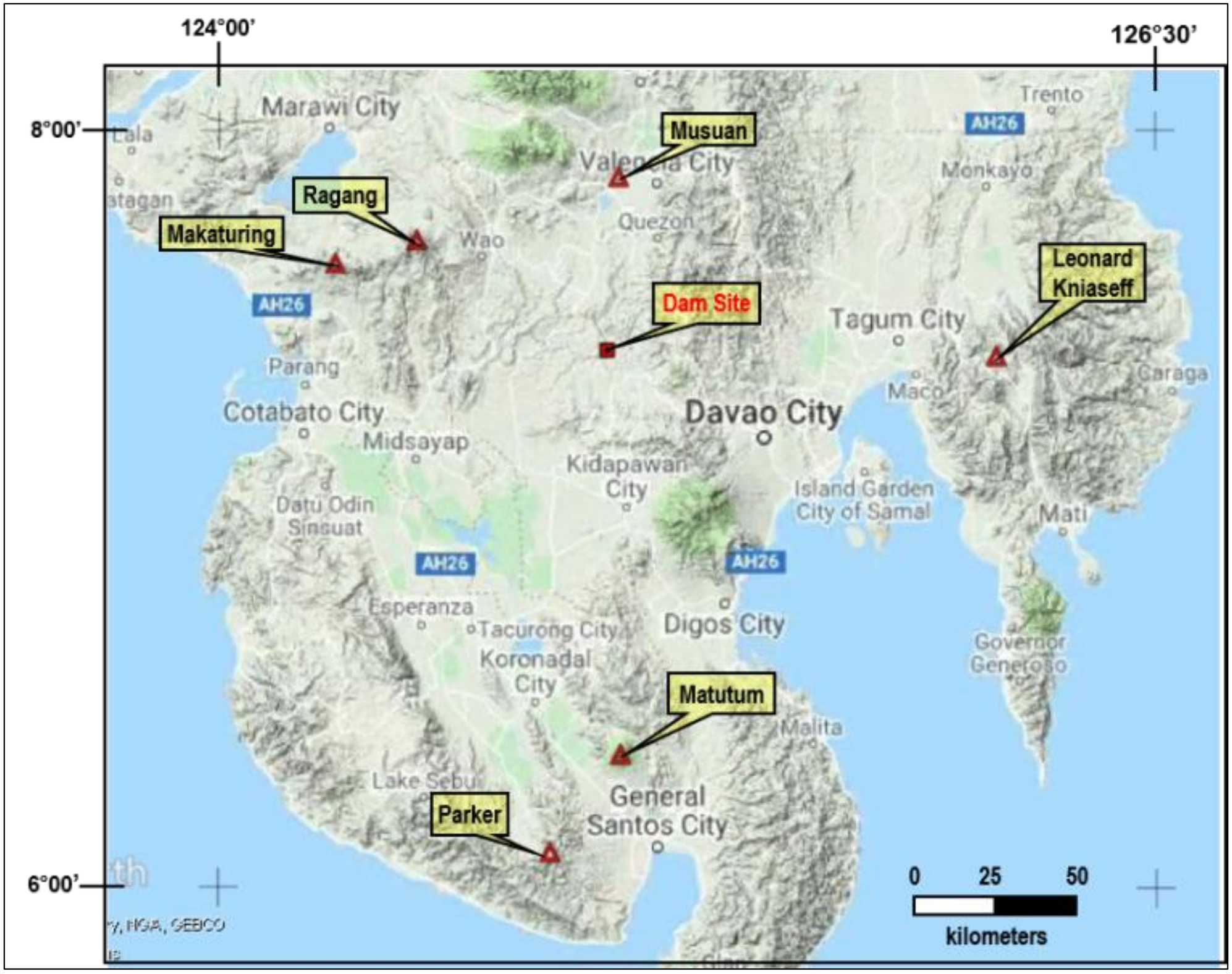
Table 4-3: Active[5] Volcanoes in Mindanao in Relation to the Project.
(Source: PHIVOLCS)

Name of Volcano	Provincial Location	Last Known Activity	Approx. distance and bearing from dam site*
Musuan	Bukidnon	1867	50 km N04°E
Ragang	Lanao del Sur	1916	63 km N60°W
Makaturing	Lanao del Sur	1882	85 km N73°W
Leonard Kniaseff	Compostela Valley	120 AD ± 100 years**	112 km due E
Matutum	South Cotabato	1911	118 km S 03 E
Parker	South Cotabato	1641	147 km S06°W

* Distance and bearing measured using Google Earth.
** Smithsonian Institution Global Volcanism Program in Wikepedia

Given the remoteness of the active volcanoes, the volcanic hazard that could potentially affect the project will be from ashfall depending on the intensity of eruption and prevailing wind direction.

[5] PHIVOLCS categorizes an active volcano as having erupted within historical times (within the last 600 years), accounts of these eruptions were documented by man; erupted within the last 10,000 years based on the analyses of material from young volcanic deposits.



Lichel Technologies, Inc. Unit 1403 Prestige Tower Condominium F. Ortigas, Jr. Road, Ortigas Center, Pasig City	FIGURE TITLE : **Active Volcanoes in Relation to the Project Site**	FIGURE NO.: **4-4**

4.1.4 Hydrological Hazards

MGB classifies hydrologic hazards as either fluvial (inland) or coastal hazards with the former as the relevant hydrological hazard. The project is susceptible to fluvial hazards such as of flooding, channel erosion, rill and gully erosion, and sedimentation.

4.1.4.1 Flooding

The MGB geohazard map in **Figure 4-2** also shows the flood susceptible areas in relation to the project area. The MGB ratings for flood susceptibilities are the following:

Very High:	Areas to experience flood heights of greater than 2 meters and/or flood duration of more than 3 days. These areas are immediately flooded during heavy rains of several hours; include landforms of topographic lows such as active river channels, abandoned river channels and area along river banks; also prone to flashfloods.
High:	Areas likely to experience flood heights of greater than 1 up to 2 meters and/or flood duration of more than 3 days. These areas are immediately flooded during heavy rains of several hours; include landforms of topographic lows such as active river channels, abandoned river channels and area along river banks; also prone to flashfloods.
Moderate:	Areas likely to experience flood heights of greater than 0.5 up to 1 meter and/or flood duration of 1 to 3 days. These areas are subject to widespread inundation during prolonged and extensive heavy rainfall or extreme weather condition. Fluvial terraces, alluvial fans, and infilled valleys are moderately subjected to flooding.
Low:	Areas likely to experience flood heights of 0.5 meter or less and/or flood duration of less than 1 day. These areas include low hills and gentle slopes. They also have sparse to moderate drainage density.

The active channel of Pulangi River has very high flood susceptibility while low-lying areas adjacent to the river have high flood susceptibility. However, it should be noted that these low lying areas will eventually be submerged by the reservoir. Residents living in these areas will have to be relocated to higher and safer grounds.

The project will help to control the flood flows of Pulangi River that could alleviate the flooding experienced in the lowlands of Cotabato City.

4.1.4.2 Erosion and Sedimentation

Soil erosion by water, whether naturally occurring or as a result of anthropogenic activities, occurs in varying stages from splash erosion to gully erosion. Eroded sediments would eventually enter stream channels which could undergo bank erosion. The proposed dam will have a dead storage capacity of 495 million cubic meters (MCM) which is allotted for sediments. At a present sedimentation rate estimated at 8 MCM per year, the dead storage could be filled-up in 62 years, which is beyond the normal lifetime of a hydropower plant of 50 years. Without the dam the eroded sediments would have otherwise continued to move downstream. The proponent should pursue project sustainability efforts such as watershed management and protection in partnership with concerned stakeholders.

4.1.5 Risks Associated with Dams and Other Structures

4.1.5.1 Hydrological Risks

The risks associated with hydraulic failure of dams are:

- overtopping of the dam resulting to erosion and slope instability of the embankment;
- surface embankment erosion; and
- piping (internal erosion) and seepage.

Overtopping of the dam embankment is a continuous flow as water surface elevation exceeds the elevation profile of the dam. Overtopping of dam occurs when the reservoir inflow exceeds the available storage and/or the spillway discharge capacity. In the Risk Communication Fact Sheet of the U.S. Federal Emergency Management Agency (FEMA), overtopping of dams accounts for approximately 34% of all dam failures in the U.S.

As stated earlier, the dam will also function as a control flood structure. The dam will have a reservoir storage of 1169.3 MCM. To prevent overtopping, the dam will have sufficient freeboard which is composed of a surcharge height and a dry freeboard. The dam will have adequate spillway capacity to ensure that water does overflow and damage the dam.

The engineered design of the dam will have the appropriate embankment protection. The proposed dam embankment will have a rockfill core with a concrete slab constructed at the upstream face of the dam.

Piping is the internal erosion of the foundation or embankment caused by seepage. Generally, erosion starts at the downstream toe and works back toward the reservoir, forming channels or pipes under the dam. The channels or pipes follow paths of maximum permeability and may not develop until many years after construction. Resistance of the embankment or foundation to piping depends on (i) plasticity of the soil; (ii) the gradation; and (iii) the degree of compactness.

Plastic clays with a plasticity index >15, for both well and poorly compacted are the materials which are most resistant to piping. Minimum piping resistance is found in poorly compacted, through to well-graded cohesionless soils with practically no binder. It is also found in uniform, fine, cohesionless sand, even when well compacted. Settlement cracks in resistant materials may also produce piping.

Piping can be avoided by lengthening the flowpaths of water within the dam and its foundations. This decreases the hydraulic gradient of the water flow and hence its velocity. The flowpaths can be increased by:

- cutoff walls;
- impermeable cores; and
- Impermeable blankets (grouts) extending upstream from the upstream face.

Seepage is the continuous movement of water from the upstream face of the dam toward its downstream face. The upper surface of this stream of percolating water is known as the phreatic surface. The phreatic surface should be kept at or below the downstream toe. The phreatic surface within a dam can be controlled by properly designed cores or walls.

Internal drainage system (drainage gallery) is included in the design to reduce the pore water pressures in the dam thus increasing the stability of the downstream slope against sliding and to control any seepage that exits the downstream portion of the dam and prevent downstream piping.

Whilst adequate embankment protection against erosion is included in the dam design, and erosion control measures will be implemented at all project areas, erosion, particularly gully erosion, of cleared lands in the entire dam catchment areas will persist. The proponent should identify areas that are prone to massive erosion and adopt appropriate mitigating measures to minimize this impact.

4.1.5.2 Reservoir-Triggered Seismicity

Reservoir-triggered seismicity (RTS) is described as earthquake events that are triggered by the filling of a reservoir, or by water-level changes or during operation of the reservoir. Seismic events have occurred near large dam sites or in reservoir areas and may have been triggered by changes in the physical environment as a result of impounding and operation of reservoirs. ICOLD (2004) believed that RTS primarily represents the release of pre-existing tectonic strain (fault), with the reservoir being only a perturbing influence. Thus, the reservoir does not cause or induce the seismicity, it merely triggers the release of the accumulated, naturally occurring tectonic strain that already existed. In this regard, the term “triggered seismicity” is currently preferred over “induced seismicity” (the former terminology used until about the late 1980’s). RTS events occur only as a result of the incremental effects of reservoir load and the build-up of pore water pressure to make them happen.

ICOLD (2004) presented about 40 cases of RTS. The number of RTS cases worldwide is small compared to more than 10,000 reservoirs without any experiencing any such activity. The earthquake magnitudes reported by most of the reservoir induced seismicity cases were small, being M 5.5 or less. Only a few suspected cases experienced an induced earthquake of greater than magnitude 6. These include:

- M 6.5 at the 103 m high Koyna Dam in India
- M 6.3 at the 120 m high Kremasta Dam in Greece
- M 6.1 at the 105 m high Hsinfengkiang Dam in China
- M 6.0 at the 120 m high Kariba dam in Zambia.

None of these cases had a magnitude greater than M 6.5. The consideration of the RTS has been reported as generally linked to dams higher than about 100 m or to large reservoirs (capacity greater than about 500 million cubic meters) and to new dams of smaller size located in tectonically sensitive areas.

It is generally accepted that reservoir filling will not cause damaging earthquakes in locations where they would not otherwise occur. In high seismic areas, dams are designed to withstand very strong shaking due to the maximum design earthquake (MDE). Seismic hazards due to RTS are:

- ground shaking: vibrations in dams, appurtenant structures, equipment and foundations;
- mass movements into reservoir and rockfalls at dam site: impulse waves in reservoir; blockage of intakes; damage of hydro-mechanical and electro-mechanical equipment, and other damage;
- fault movements in dam foundation;
- fault displacement in reservoir bottom: water waves in reservoir or loss of freeboard; and
- noise

While there exist differences of technical opinion regarding the conditions which cause RTS, it should be considered as a credible event if the proposed reservoir contains active faults within its hydraulic regime and if the regional and local geology and seismic record within that area are judged to indicate potential for reservoir-triggered seismicity. Even if all the faults within a reservoir are considered tectonically inactive, the possibility of reservoir-triggered seismicity should not be totally ruled out, if the local and regional geology and seismicity suggest that the area could be subject to reservoir-triggered seismicity.

Reservoir triggered ground motion should in no case be greater than the MCE ground motion and the faults considered capable of triggering seismicity should be taken into consideration during the seismic hazard evaluation. Still the result might be the premature triggering of seismic events due to the impounding of the reservoir that would have occurred naturally at some longer time in the future. It is therefore justified in case of larger dams and storages located in seismically active regions and

regions with high tectonic stresses to install a microseismic network and to monitor the seismicity prior to, during and after impounding (ICOLD, 2004).

4.1.5.3 Settlement

Settlement is the settling of a material (soil) resulting from the load imposed by a structure. The unequal settling of a material is termed differential settlement. When all parts of a structure rest on the same kind of soil, and the loads on the structure and the design of its structural system are uniform throughout, differential settlement is normally not a concern. Where soils, loads, or structural systems differ between parts of a structure, different parts of the building structure may settle by substantially different amounts. Excessive differential settlement can cause foundation failures.

It is necessary to determine the load bearing capacity of the soil and estimate settlement of the planned structure. An allowable bearing capacity is the maximum bearing stress that can be applied to a foundation such that if is safe against instability due to shear failure and the maximum tolerable settlement is not exceeded.

It is imperative that the construction of the dam embankment strictly follows the design specifications. A Quality Control Plan should be developed to perform quality control testing of the compaction of embankment material.

4.2 Physical and Chemical Risk

4.2.1 Description of Possible Major Accident Scenarios

4.2.1.1 Blasting Operations

Blasting may be utilized during the construction phase. The following are the significant hazards associated with blasting:

a) Injury and death resulting from the blasting procedure; from the hole drilling, explosive application, setup of blasting cords and primers, to the explosion itself;
b) Resulting dust and gas generation from the explosive application to detonation;
c) Vibration from the explosion; and
d) Flying rock debris resulting from the explosion.

4.2.1.2 Explosive Storage and Handling

The following are the hazards that may rise from this activity:

a) Explosive theft or pilferage;
b) Premature detonation of blasting caps and cords during handling and transport; and
c) Exposure to volatile organic compounds (VOCs) inside the magazine.

4.2.2 Information Relating to the Safety Management System for the Establishment

The company will formulate if non-existent, and implement the following protocols during the construction and operational phases to ensure that the operation of its proposed project is hazard-free as possible and the factors leading to an accident are minimized:

- Emergency Response Procedures Manual
- Road Transport Safety Management System Manual
- Material Safety Data Sheet Database
- Blasting Accident Reports and Procedures
- Procedures on Handling and Use of Explosives

These protocols are to be used to prevent accidents and fatalities during emergency cases and in handling hazardous materials on-site.

5 SOCIAL DEVELOPMENT FRAMEWORK AND IEC FRAMEWORK

5.1 Social Development Plan Framework

5.1.1 Background/Rationale

The Social Development Plan Framework (SDPF) will address the issues and concerns and impacts identified during the consultations and discussions with the affected communities. It will incorporate the proposed interventions based on needs of various stakeholders of the project.

As part of its social responsibility, the proponent will aim to provide basic social services and empower the stakeholders, especially the affected residents as partners for sustainable development.

It will also strive to develop strategies that will alleviate poverty and improve the standard of living of communities through socio-economic programs and projects that will harness affected residents' productivity to the fullest, strengthen their self-reliance values and enhance their dignity as members of civil society.

5.1.2 Basic Features of the SDP

The SDP framework is based on the sustainable development and self-reliance approaches. Its goal is to empower communities and stakeholders to undertake sustainable development efforts even after the decommissioning of the project.

The full benefits of the project should be able to trickle down to the most disadvantaged and vulnerable sectors of affected communities. The participation of these vulnerable sectors (youth, women, elderly, persons with disability, fishermen, farmers, small traders and enterprise owners, etc.) as "partners" of development activities in the affected Barangays should be ensured from planning, implementation to evaluation of identified projects. In addition, benefits may also be received by members through the social programs of the irrigators association such as increased knowledge and techniques for agriculture, agricultural technology transfers from the association to the members, and possible financial assistance to name a few .

The SDP should be able to complement the existing Municipal/Provincial Development Plans and consider their basic priorities identified by the LGUs, and more importantly, the project impact and stakeholders' concerns and issues.

5.2 Information, Education And Communication Framework

5.2.1 Background/Rationale

The Information, Educational Communication (IEC) Plan Framework is an important tool in establishing harmonious relationship between the proponent and project stakeholders. It opens the line of an open interaction that will critically identify issues and concerns on the part of project stakeholders and a responsive mitigation measures to be developed by both project proponent and project stakeholders. The IEC plan goes beyond the objective of providing information or conducting dissemination activities. It focuses on providing on-going interaction between the proponent and stakeholders during the construction, operation and decommissioning phases. It provides information on the milestones and progress of development and issues during implementation stages. More meaningfully, IEC program will inculcate value formation by making the community and residents aware of their roles as project stakeholders. When the IEC program is conducted effectively, it is a significant confidence and trust-building tool for both the project stakeholders and the project proponent.

5.2.2 Goals and Objectives

The IEC plan will seek to reach a broad-based population of various project stakeholders and sectoral groups that will be directly or indirectly affected by the project. It promotes a better understanding of the issues and concerns of the project stakeholders and the proponent, for the resolution of the issues and concerns through acceptable planned mitigation measures.

Specific Objectives:

- To provide better appreciation of the project goals and objectives, project description and components, identified impacts and corresponding social concerns and issues on the part of the project stakeholders, mitigation measures and project benefits
- To clarify misinformation and vague ideas about the project to reduce negative reactions as well as informed-decision among project stakeholders.
- To establish trust and confidence between stakeholders and the project proponent to pursue pro-active approaches and strategies to mitigate potential impacts and to enjoy an equitable distribution of the benefits of the project

Table 5-1: Social Development Plan Framework

	CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
1.	**Gender Responsive Livelihood / Employment (Men, Women, Youth and Elderly)**					
	Skills training	-Qualified Project Affected Men, Women, Youth and Elderly	• LGU- Planning and Development Coordinator • MSWD • TESDA • DOLE	Community Developmnent Officer	• Pre-construction • Construction	LGU –IRA/ PHPC Communtiy Developemnt Program
2.	**Health and Safety**					
	IEC on safety for employees IEC for residents on safety DRRM and Emergency Response	-Barangay Kagawad for Health -Project Affected Community	• PHPC • LGU MHO/RHU • Barangay Disaster Management	Community Developmnent Officer	• Pre-construction • Construction • Operation	LGU –IRA/ PHPC Communtiy Developemnt Program
3.	**Environment and Sanitation**					
	Accumulation of domestic and animal wastes in the dowstream areas	-Barangay Kagawad for Environment -Project Affected Community -IA Officers	• Municipal/City MHO/RHU	Community Developmnent Officer	• Pre-construction • Construction • Operation	LGU –IRA/ PHPC Communtiy Developemnt Program
	Security of Water Supply-identification of alternative sources and/or provision of potable water in areas with water quality below gudielines.	-Barangay Kagawad for Environment -Project Affected Community	• Muncipal/City ENRO • PHPC • Local Water Districts	Community Developmnent Officer	• Pre-construction • Construction • Operation	LGU –IRA/ PHPC Communtiy Developemnt Program
	Watershed Management	PHPC, Project Affected Community	• PHPC • LGU	Community Developmnent Officer	• Construction • Operation	LGU –IRA/ PHPC Communtiy Developemnt Program
4.	**Peace and Order**					
	Entry of migrant workers	-Barangay Kagawad for Peace and order -Project Affected Community	• LGU • PNP	Community Developmnent Officer	• Pre-construction • Construction • Operation	LGU –IRA/ PHPC Communtiy Developemnt Program

Table 5-2: Information, Education and Communication Plan Framework

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to Project	IEC Scheme/Strategy/ Methods	Information Medium	Indicative Timelines and Frequency	Indicative Cost
a. Residents of Affected Barangays	1. Project description and status 2. Objective of EIA study/EIA Findings 3. Issues and concerns about the project 4. Building Trust and confidence 5. Rights and responsibilities of stakeholders/pro-active response to project operations: Monitoring/creation of MMTs 6. DRR program; presentation of areas at high risk to flooding and landslide; communicating of possible scenarios during dam break and emergency response	• Community assemblies • Group discussions • Interpersonal/CO approach • Deployment of IDO Staff for continuing dissemination of information/organization of information/gatekeepers and peer facilitators	• Invitation letters • Primer about the project • Study tours to sites with good practice • Hand-outs on MMT creation, task and responsibilities • Flyers/Billboards/Public Information Brochure	• Pre-construction • Construction Phase (semiannually) • Operation Phase (semiannually) • Decommissioning Phase (semiannually for 2 years)	• Php 500,000
b. LGU: Provincial, Municipal and Barangay Units	1. Project description and status 2. Project Impact 3. Objective of EIA Study/EIA Findings 4. Issues and concerns about the project 5. Mitigation measures	• group methods • group workshops • group discussion • Interpersonal/ CO approach • one-on-one meetings • group workshop/	• Invitation Letters • One-on-one meetings • Primer about the project and EIA study • Study tours to sites with good practice • Flyers/Billboards/Public	• Pre-construction • Construction Phase (semiannually) • Operation Phase (semiannually) • Decommissioning Phase (semiannually	• Php 500,000

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to Project	IEC Scheme/Strategy/ Methods	Information Medium	Indicative Timelines and Frequency	Indicative Cost
	6. Building Trust and Confidence that mitigation measures will be undertaken 7. Rights and responsibilities of stakeholders/pro-active response to operations: Monitoring/creation of MMTs 8. Results of water quality assessment and its health implications 9. DRR program; presentation of areas at high risk to flooding and landslide; communicating of possible scenarios during dam break and emergency response	discussion	Information Brochure • Hand-outs on MMT and IA creation, task and responsibilities	for 2 years)	
c. Sectoral Groups (farmers, fishermen, women, etc.)/NGOs, POs	1. Project description and status 2. Project Impact 3. Objective of EIA Study/ 4. EIA Findings 5. Concerns about the project's potential negative impact 6. Project benefits (community assistance, training, enterprise development, livelihood and employment, etc. 7. Rights and responsibilities of stakeholders/pro-active	• Group methods • Community Consultations/ assemblies • Group Discussion	• Invitation Letters • One-on-one meetings • Primer about the project and EIA study • Study tours to sites with good practice • Hand-outs on MMT creation,	• Pre-construction • Construction Phase (semiannually) • Operation Phase (semiannually) • Decommissioning Phase (semiannually for 2 years) •)	• Php 500,000

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to Project	IEC Scheme/Strategy/ Methods	Information Medium	Indicative Timelines and Frequency	Indicative Cost
	response to project operations: Monitoring/creation of MMTs 7. Results of water quality assessment and its health implications 8. DRR program; presentation of areas at high risk to flooding and landslide; communicating of possible scenarios during dam break and emergency response		task and responsibilities		
d. Concerned agencies (DOE, NIA, DENR, DAR, DA, DSWD, DepEd, DOH, DOLE etc.)	1. Project Description and Status 2. Project Impact 3. Issues and Concerns about the project 4. Mitigation Measures 5. Rights and responsibilities of stakeholders/pro-active response to project operations: Monitoring/creation of MMTs 6. Results of water quality assessment and its health implications 7. DRR program; presentation of areas at high risk to flooding and landslide; communicating of possible scenarios during dam break and emergency response	• Community assembly • Group workshop/ discussion • Group workshop/ discussion • group workshop/ discussion	• One-on-one meetings • Primer about the project and objectives of EIA • Group discussion • SDP presentation • Study tours to sites with good practice • Hand-outs on MMT creation, task and responsibilities • Flyers/Billboards/Public Information Brochure	• Pre-construction • Construction Phase (semiannually) • Operation Phase (semiannually) • Decommissioning Phase (semiannually for 2 years) •	• Php 500,000

6 ENVIRONMENTAL COMPLIANCE MONITORING

6.1 Self-Monitoring Plan

Design, review and construction supervision by an independent consultant is highly recommended to ensure QA/QC during construction. The sources of construction material should be regularly sampled and tested for their suitability as construction material (e.g. grain size analysis, natural moisture content, consolidation test). It is recommended that compaction tests, either by neutron density meter or by sand cone testing, be conducted every third lift of the embankment.

The dam should be subjected to quarterly visual inspection – monthly monitoring during the rainy season. The dam should also be visually inspected after strong typhoons for: landslides, slumping, tension cracks, seepages (location and number of seepages, volume of seepages, turbidity), scouring, log jams, etc.

Structures should usually be monitored for log jams during typhoons or during prolonged periods of intense rainfall and that personnel and equipment be made available to unclog the spillway if necessary. However, it should be noted that the proposed structure is designed as an overflow dam.

It is also highly recommended that the dam and its appurtenant structures be visually inspected after a major earthquake. The dam should be inspected for, among other things: cracks, settlement, landslides, slumping, seepages, and piping.

The primary purpose of an environmental monitoring plan is to ensure the judicious implementation of sound environmental management in effecting of project activities. It is designed to monitor the compliance with conditions included in the ECC, environmental rules and standards, and other commitments stipulated in the EMP. It can also be a basis for effective planning and management of environmental measures necessary to the Project. A summary of the various elements of the environmental monitoring plan is provided in **Table 6-1**

6.1.1 Soil Quality

Soil quality monitoring will be undertaken quarterly for the duration of the construction phase. Physico-chemical characteristics of the soil shall be monitored for changes. This aims to immediately identify any changes in soil profile during construction phase and to apply appropriate remedial measures.

6.1.2 Air Quality and Noise

During construction, air quality monitoring will be undertaken to monitor concentrations of TSP (using High Volume Sampler) at the sampling stations established including additional stations at the boundary of the construction site. Likewise, noise monitoring will be undertaken at the periphery of the site and at sensitive receptors (e.g. schools and residential areas). The primary aim of the noise monitoring during the construction period is to respect sleeping and resting periods of residents near the construction site.

6.1.3 Water

Water quality monitoring will consist of the river water quality monitoring. During construction, surface water quality monitoring will be undertaken at the selected sampling on a monthly basis. During operation, surface water quality monitoring will be conducted upstream and downstream of the river, as well at the discharge point.

Table 6-1: Environmental Monitoring Plan

Project Phase / Environmental Aspect	Potential Impact per Envtl Sector	Parameters to be monitored	Sampling and Measurement Plan			Lead Person	Annual Estimated Cost	EQPL Management Scheme					
			Method	Frequency	Location			EQPL Range			EQPL Management Scheme		
								Alert*	Action**	Limit	Alert*	Action**	Limit
II. CONSTRUCTION PHASE													
Environmental Aspect #1: Site Preparation (Clearing, Grubbing, Stripping)	Soil Erosion	Sediment Yield	Grab Sampling	Quarterly	Construction areas	PHPC Envi Unit	Php 200,000	470 tons/km^2/ yr	475 tons/km^2/yr	480 tons/km^2/yr	Inform responsible group Check stability of erosion control measures	Limit personnel and movement in the area. Place hazard signs Employ additional erosion control measures, as possible	Clear eroded area of all persons, evaluate options for mitigation Cease earthworks activities Review Construction Plan
	Geologic Hazards: Landslides and slope failures	Cracks in slopes	Visual inspection/ absence or presence	Monthly	Construction areas			Presence of cracks/loose soils	-	-	Install surface drain system to reduce stormwater over the slopes		
	Terrestrial Ecology: Removal of vegetation on construction areas	# of individuals (endemic, vulnerable, endangered, critically endangered species) (IUCN classification and DAO 2017-11)	Species Inventory	Semi-annual	Construction Sites	PHPC Envi Unit	Php 1,000,000	5% increase from inventory	10% increase from inventory	15% increase from inventory	Reiterate construction plan to workers Compensate through planting indigenous species for rehabilitation	Reiterate construction plan to workers Compensate through planting indigenous species for rehabilitation	Cease earthworks activities Review Construction Plan Compensate through planting indigenous species for rehabilitation
	Terrestrial Ecology: Temporary disturbance of terrestrial fauna	Species Richness of Fauna	Visual Observation and Listings	Semi-annual	Critical habitats and/or forest areas	PHPC Envi Unit	Php 1,000,000	Baseline levels -15% decrease in species richness for two consecutive monitoring period richness	Baseline levels -25% decrease in species richness for two consecutive monitoring period	Baseline levels -30% decrease in species richness for two consecutive monitoring period	Investigate possible cause of decline: project-related or anthropogenic If project-related, alert project management If anthropogenic, enhance enfɔcement;	If project-related, alert project management If anthropogenic, enhance enfɔcement;	If project-related, Cease earthworks activities, then Review Construction Plan If anthropogenic, joint investigation with LGUs, DENR and MMT, then formulate corrective action as agreed upon by investigative group.
	Water Quality: Increased Siltation and Sedimentation due to soil erosion of exposed soil surface	Total Suspended Solids (TSS) (increase from baseline)	Grab Sampling	Quarterly	Downstream of civil works activities	PHPC Envi Unit	Php 100,000	70 mg/L	75 mg/L	80 mg/L	Identify cause	Check the integrity of silt traps in the area and repair/reinforce if necessary	Limit earthworks from a distance away from the waterways, as applicable Suspend earthworks as necessary until parameter normalizes, if identified as cause
	Water Quality: Contamination of Surface Waters due to increased Solid and Liquid Wastes.	DO	Grab Sampling	Quarterly	Downstream of civil works activities	PHPC Envi Unit	Php 1,000,000	5.5 mg/L	5.3 mg/L	5 mg/L	Identify potential source	If project-related, employ applicable management measures, as necessary	Suspend identified activity/source of exceedance until corrective action has been proven effective
		BOD						5	3	1			
		Cd						0.001	0.002	0.003			
		Cr						0.005	0.008	0.01			
		Cu						0.015	0.018	0.02			
		Pb						0.005	0.008	0.01			

Project Phase / Environmental Aspect	Potential Impact per Envtl Sector	Parameters to be monitored	Sampling and Measurement Plan: Method	Frequency	Location	Lead Person	Annual Estimated Cost	EQPL Management Scheme: EQPL Range — Alert*	Action**	Limit	EQPL Management Scheme — Alert*	Action**	Limit
		Hg						0.0005	0.0008	0.0001			
		As						0.005	0.008	0.01			
	Freshwater Ecology: Riverbank disturbance	RCE	Plankton; fish; macro-invertebrates;	Semi-annual	FWE Sampling Stations	PHPC Envi Unit	Php 1,000,000	Decrease in quantitative score but not quality /	Decrease in quantitative score and borderline decrease in quality /	Decrease in quantitative score and drastic decrease in quality –	Data verification cause analyses	Cause analyses and mitigation	Cause analyses and immediate mitigation
	Freshwater Ecology: Aquatic Ecology	Species Richness											
	Air Quality and Noise: Potential increase in Total Suspended Particulate (TSP), and Noise Levels within and around the Project site.	TSP,	TSP = High Volume /Gravimetric	Quarterly	Air Quality Sampling Stations	PHPC Envi Unit	Php 500,000	TSP 250 µg/Ncm			Identify potential source.	If project-related, employ applicable management measures, as necessary.	Suspend identified activity/source of exceedance until corrective action has been proven effective.
		Noise	Noise = Noise Meter					Cat: A; D: 50; ME: 45; N: 40	TSP 275 µg/Ncm: Cat: A; D: 53; ME: 48; N: 43	TSP 300 µg/Ncm: Cat: A; D: 55; ME: 50; N: 45			
Environmental Aspect #2: Earthworks generation and exposure of loose soil	Geologic Hazards: Landslides and slope failures	Cracks in slopes	Visual inspection/ absence or presence	Monthly	Construction areas	PHPC Envi Unit		Presence of cracks/loose soils	-	-	Install surface drain system to reduce stormwater over the slopes		
	Water Quality: increased sedimentation and siltation of rivers	Total Suspended Solids (TSS) (increase from baseline)	Grab Sampling	Quarterly	Downstream of civil works activities	PHPC Envi Unit	Php 100,000	70 mg/L	75 mg/L	80 mg/L	Identify cause	Check the integrity of silt traps in the area and repair/reinforce if necessary	Limit earthworks from a distance away from the waterways, as applicable Suspend earthworks as necessary until parameter normalizes, if identified as cause
	Water Quality: Water contamination from solid and liquid wastes	DO	Grab Sampling	Quarterly	Downstream of civil works activities	PHPC Envi Unit	Php 1,000,000	5.5 mg/L	5.3 mg/L	5 mg/L	Identify potential source	If project-related, employ applicable management measures, as necessary	Suspend identified activity/source of exceedance until corrective action has been proven effective
		BOD						5	3	1			
		Cd						0.001	0.002	0.003			
		Cr						0.005	0.008	0.01			
		Cu						0.015	0.018	0.02			
		Pb						0.005	0.008	0.01			
		Hg						0.0005	0.0008	0.0001			
		As						0.005	0.008	0.01			
	Potential increase in Total Suspended Particulate (TSP) and Noise	TSP,	TSP = High Volume /Gravimetric	Quarterly	Monitoring stations for quarterly monitoring to be located at the	PHPC Envi Unit	Php 500,000	TSP 250 µg/Ncm			Remove loose material from slopes	If project-related, employ applicable management measures, as necessary	Suspend identified activity/source of exceedance until corrective action has been proven effective
		Noise	Noise = Noise Meter					Cat: A; D: 50; ME: 45; N: 40	TSP 275 µg/Ncm: Cat: A; D: 53; ME: 48; N: 43	TSP 300 µg/Ncm: Cat: A; D: 55; ME: 50; N: 45			
	Health and Safety: Increased accidents to people in communities	# of accidents	Audit health and safety	Continuous	Construction areas	PHPC Safety/ Community Relations	Php 200,000	1% increase in accidents	2% increase in accidents	3% increase in accidents	Inform Responsible Entity	Improve signages and re-orient workers of safety protocol	Re-evaluate safety protocol and implement changes
Environmental Aspect #3: Actual Construction of Structures	Geologic Hazards: Landslides and slope failures	Cracks in slopes	Visual inspection/ absence or presence	Quarterly	Construction areas	PHPC Envi Unit		Presence of cracks/loose soils	-	-	Remove loose material from slopes		
	Water Quality: Water contamination from solid and liquid	DO	Grab Sampling	Quarterly	Downstream of civil works activities	PHPC Envi Unit	Php 1,000,000	5.5 mg/L	5.3 mg/L	5 mg/L	Identify potential source	Review waste management practices	Suspend construction of structures until corrective action has
		BOD						5	3	1			
		Cd						0.001	0.002	0.003			

Project Phase / Environmental Aspect	Potential Impact per Envtl Sector	Parameters to be monitored	Sampling and Measurement Plan: Method	Sampling and Measurement Plan: Frequency	Sampling and Measurement Plan: Location	Lead Person	Annual Estimated Cost	EQPL Management Scheme: EQPL Range: Alert*	EQPL Range: Action**	EQPL Range: Limit	EQPL Management Scheme: Alert*	EQPL Management Scheme: Action**	EQPL Management Scheme: Limit
	wastes	Cr						0.005	0.008	0.01		If project-related, employ applicable management measures as necessary, such as containment of solid and liquid wastes	been proven effective
		Cu						0.015	0.018	0.02			
		Pb						0.005	0.008	0.01			
		Hg						0.0005	0.0008	0.0001			
		As						0.005	0.008	0.01			
	Air Quality: Potential increase in Total Suspended Particulate (TSP) and Noise	TSP	TSP = High Volume /Gravimetric	Quarterly	Air Quality Sampling Stations	PHPC Envi Unit	Php 500,000	TSP 250 µg/Ncm	TSP 275 µg/Ncm	TSP 300 µg/Ncm	Identify potential Source	If project-related, employ applicable management measures as necessary, such as checking and repairing vehicles and equipment	Suspend construction of structures/ source of exceedance until corrective action has been proven effective
		Noise	Noise = Noise Meter					Cat A: D 50, ME 45, N 40	Cat A: D 53, ME 48, N 43	Cat A: D 55, ME 50, N 45			
III. OPERATION PHASE													
Environmental Aspect#1: Operations in Dam and Reservoir	Soil Quality: Contamination of Soils	pH	Electrometric	Annual	Service Area	PHPC Envi Unit	Php 500,000	5.5 & 8.0	5.7 & 8.3	5.5 & 8.5	Identify potential source	If project related, Inform Farm lot owners and LGUs Containment of contaminants from identified source.	If project related, Inform Farm lot owners and LGUs Containment of contaminants from identified source until corrective action has been proven effective.
		Potassium	Flame AAS					110 mg/kg	105 mg/kg	100 mg/kg			
		Phosphorus	Colorimetric					11.5 mg/kg	11.3 mg/kg	11.0 mg/kg			
	Hazards: Flooding of downstream Communities due to heavy rainfall	Water Level of Reservoir	Height Measuring	Daily	Rain Gauge Stations	PHPC Envi Unit		High Dam = 152 m Afterbay Dam = 60 m	High Dam = 155 m Afterbay Dam = 63 m	High Dam = 158.36 m Afterbay Dam = 66.28 m	Inform communities downstream Follow water releasing protocols	Inform communities downstream Commence Water Releasing Protocols	Gradual Release of water from the Dam Re-evaluate releasing of water procedures, implement changes
	Freshwater Ecology: Riverbank disturbance	RCE	Plankton; fish; macro-invertebrates;	Semi-annual	FWE Sampling Stations	PHPC Envi Unit	Php 500,000	Decrease in quantitative score but not quality /	Decrease in quantitative score and borderline decrease in quality /	Decrease in quantitative score and drastic decrease in quality –	data verification cause analyses /	Cause analyses and mitigation/	Cause analyses and immediate mitigation
	Freshwater Ecology: Aquatic Ecology	Species Richness											
Environmental Aspect # 2: Aquaculture	Nutrient Loading in Reservoir Waters	Nitrate, Phosphate	Grab Sampling	Quarterly	Reservoir Fish Cages	PHPC Envi Unit	Php 200,000	Class A N (mg/L) 9 P (mg/L) 0.45	Class A N (mg/L) 9.5 P (mg/L) 0.47	Class A N (mg/L) 10 P (mg/L) 0.5	Evaluate feeding schedules/frequency, then implement changes	Re-evaluate feeding schedules, then implement changes.	Re-evaluate Feedin Schedules, until correctiv action has been prove effective
Project Abandonment													
Should the Project be abandoned or decommissioned after its economic life, the proponent will provide DENR with the abandonment/decommissioning plan, two (2) years before its actual date of abandonment/decommissioning.													

*, **:Final values for alert and action will be finalized with MMT

For aquatic ecology, the first monitoring activity shall serve as the baseline conditions for monitoring. 3 stations shall be established for this purpose covering the areas upstream of the dam site, downstream of the dam site. This should be done quarterly during the construction phase and quarterly during the operations phase.

Stream flow measurement will be conducted quarterly during the construction phase. This is to determine any variation or changes in water flow during the construction of the project components. Monitoring of stream flow will also be done during the operation phase.

6.1.4 People

The socio-economic monitoring will consist of monitoring the influx of workers during construction period and local employment for the operational phase. The distribution of benefits will also be monitored annually during the operational phase of the Project.

6.2 Multi-Sectoral Monitoring Framework

The Multi-partite Monitoring Team (MMT) shall be formed and organized in accordance with Article IV, Sections 15-19 of DENR DAO 2017-15. The MMT will serve as venue for promoting grater stakeholder vigilance and providing appropriate check and balance mechanisms in monitoring project impacts as well as venue for empowering the communities in taking responsibility for environmental protection (Sec 15.2). As stipulated in Section 16.2 of DENR DAO 2017-15, the EMB and the proponent will no longer be part of the MMT. The EMB will provide oversight guidance to the MMT and consider its reports and recommendation in its impact and compliance evaluation. The Proponent will be responsible for the funds for the MMT operations based on the approved annual work and financial plan. The MMT shall be composed of the following:

- Local Government Unit representative: 1 representative from the Municipality/City (MENR/CENRO or MPDO/CPDO), 1 representative from the Provincial Government (PG ENRO or PPDO); Rural Health Unit and the Barangay Captain concerned
- 1 representative from LGU-accredited Non-government Organization
- 2 representative from locally recognized community leaders (including IPs)
- 3 represntatives (maximum) from government agencies with related mandates.
- DENR PENRO (in accordance with Section IV.A.1 of DENR Admnistrative Order 2018-18)
- DENR CENRO (in accordance with Section IV.A.1 of DENR Admnistrative Order 2018-18)

In addition, the functions of the MMT will include the following:

- Conduct quarterly ocular visit to validate the proponent's compliance with the ECC conditions and Environmental Management and Monitoring Plan including the requirement to conduct self-monitoring and submit corresponding reports regularly;
- Prepare and submit its report to EMB-CO and EMB-RO concerned using EMB-prescribed formatat least semi annually not later than July 30 for the first semester report and January 30 for the 2nd semester report
- Institute an environmental emergency and complaints receiving and management mechanism which shall include systems for transmitting recommendations for necessary regulatory action to EMB in a timely manner to prevent adverse environmental impacts.

A Memorandum of Agreement (MOA) will be entered into between the proponent and EMB-CO with conformity of the MMT Members. A MMT Manual of Operations will be formulated that will serve to guide the MMT in planning its activities, operationalize their functions and manage their performance. It will contain information on membership (selection process, code of ethics, etc.), organization

(structure, leaderhip, roles and responsibilities), fund administration and management, and activities (meetings, monitoring activities, records keeping, public disclosure, operations and perhormance enhancement.

6.3 Environmental Guarantee and Monitoring Fund

6.3.1 Environmental Guarantee Fund

The amount for the allocation of an Environmental Guarantee Fund (EGF) shall be determined based on negotiations between Proponent and EMB. An intial amount of **Php 500,000.00** for the EGF will be proposed. Once costs are negotiated, the EGF will be established through a MOA and shall be used exclusively for the following purposes:

1. Immediate rehabilitation of areas affected by damages in the environment and the resulting deterioration of environmental quality as a direct consequence of project construction, operation and abandonment;

2. Just compensation of parties and communities affected by the negative impacts of the project;

3. Conduct of scientific or research studies related to the project that will aid in the prevention or rehabilitation of accidents and/or environmental damages; and

4. Contingency clean-up activities, environmental enhancement measures, damage prevention programs and social equity measures (e.g. livelihood, social development programs) including the continuing necessary IEC and capability building activities related to the project.

If costs from the EGF are insufficient to cover compensable claims, additional costs may be covered by the Proponent. Whenever the EGF is below 50% of agreed level, it will be replenished by the Proponent. The amount may be changed at the course of Project Operations.

6.3.2 Environmental Monitoring Fund

The EMF shall be exclusively utilized to cover all costs attendant to the operation of the MMT and shall be disbursed in accordance with the guidelines stipulated in the approved MMT Manual of Operations (MOO). The EMF shall be co-managed and co-administered by MMT Secretariat in accordance with the MOO and AWFP. A proposed Monitoring Fund of Php 100,000 is set for the activities of the MMT.

7 EMERGENCY RESPONSE POLICY AND GENERIC GUIDELINES

An emergency plan shall be prepared which will be implemented with the contractor and the concerned LGUs and other participating institutions.

The plan will include the following:

1. overall safety program
2. dam monitoring
3. early warning system during storms

The dam and its appurtenant structures have to be well maintained so as to keep the facilities, as long as possible. For protection of stakeholders from dangerous deluge, damage or breach should be prevented. The maintenance works of the dam are divided into three (3) categories, which are as follows:

- Routine Works - routine inspection of the dam, its appurtenant structures and vicinities;
- Periodic Works - removal of floating obstacles around the inlet diversion dam;
- Emergency Repairs - repairs needed to the damaged facilities and structures caused by unusual weather or geological disturbances like very strong rain, big flood or devastating earthquake.

Specifically, routine works will entail the identification of warning signs on embankments and constructed structures. Settlement/displacement, seepage/leakage and cut slopes should be identified through visual inspection.

Unusual and sudden occurrences are events which take place abruptly and lead to sudden disasters. Examples of these events are flashfloods and dam break scenarios. These occurrences are to be reported immediately so that if need be, warning systems can be used as fast as possible to inform settlers located near and downstream the dam.

- Flood plain inundation maps have been prepared for five levels of flood releases;
- Warnings will be issued to those areas expected to be flooded by the releases;
- The DRD Manager and Operations Manager are responsible in notifying all concerned Civil and Military Authorities in the Region of expected discharge release from the dam and the appropriate Zone Warning
- The Civil and Military authorities shall issue zone warnings by phones, radio, public radio broadcasts and by any other possible means
- The Civil and Military authorities will supervise and assist in the evacuation of people from the affected areas and in other measures to prevent or reduce flood damages.
- Sirens should be installed in the inundation area to warn people within hearing distance.

8 ABANDONMENT/DECOMMISSIONING REHABILITATION POLICIES AND GENERIC GUIDELINES

The viability of the project depends greatly on the sustained availability of water and the reduction of the siltation of its reservoir. It is not foreseen to be abandoned but will be regularly maintained to sustain operation. Abandonment shall cover the temporary structures used during pre-construction and construction phases such as storage yards, camp house, and temporary staging areas.

In case abandonment is imperative due to force majeur or any other reasons, the structures, equipment and other related facilities may be used for other applications. Otherwise, the removal of structures, equipment and machineries from the existing site will be done to minimize possible threats to the surrounding environment.

An abandonment plan shall be formulated with consideration of the following:

- Advice and properly compensate affected employees; separation fees or compensation fees will be provided to any displaced employees;
- Machines / equipment dismantled will be sold to interested parties;
- Removal of solid, liquid and hazardous wastes within the site through a DENR-certified waste transporter/ treater;
- Clean up and possible remediation of the site, if future evaluations and testing suggest such activity is applicable; and,
- Formulation of post-abandonment land use in consultation with LGUs and stakeholders.
- Inform community of the plans to terminate the project. Provide possible assistance for post-project livelihood transition.
- Consult with stakeholders post-project use of the project area and prepare post-project plan accordingly.

9 INSTITUTIONAL PLAN FOR EMP IMPLEMENTATION

9.1 Designation of Pollution Control Officer

Current DENR guidelines provide for the appointment of Pollution Control Officer (PCO) to oversee the EMP of the company. The position should be senior and the PCO should be technically qualified to oversee the implementation of the environmental management program.

The environmental commitments of the Proponent will be thoroughly documented in the Environmental Compliance Certificate (ECC). These environmental commitments will be the minimum basis for monitoring activities by any interested party on the environmental performance of the company.

The Proponent, through its Contractor shall hire a full-time Pollution Control Officer (PCO) who will also serve as the Health, Safety and Environmental Officer. The PCO will be accredited by the DENR and shall be required to attend regular PCO training to be accustomed with the environmental regulations pertaining to the project, especially those pertaining to the air and water quality. More importantly, the PCO will be thoroughly acquainted with the environmental management and monitoring plan of the project.

9.2 Compliance Reporting

As part of the duties of the PCO, regular reporting of compliance to DENR standards and other regulatory agencies shall be undertaken. The general schedule of reporting is indicated in the environmental monitoring plan. Please refer to **Section 6.1** of the report.

9.3 Health and Safety

The Proponent shall subscribe to an active program of pursuing a healthy, safe and environment-friendly operation. It shall push for the adoption of industrial hygiene programs to ensure that a work environment shall be consistent with internationally accepted norms of industrial operations. Loss controls program, allied to the pursuit of the safety program, shall also be implemented and overseen by the PCO. In each section and shift, a safety officer shall be designated, and, together with the PCO, shall undergo health and safety training programs available from the Safety Organization of the Philippines.

Following the Company's guidelines on health and safety, it shall be made known and clear to Contractors and all employees during construction and operations. Strict compliance with these guidelines shall form part of the employees' code of conduct; sanctions and will be imposed upon violators. Safety evaluation within the Project site shall be conducted with the aim of continuously improving safety conditions.

The continuous availability of medical attention for sicknesses and medical emergencies and the provisions for first aid and emergency transport shall be made available at the Project construction site and may be shared with the nearby community.

9.4 Organizational Chart

Figure 9-1 shows the Proponent's organization in charge of environmental concerns. Their specific roles and responsibilities are further discussed.

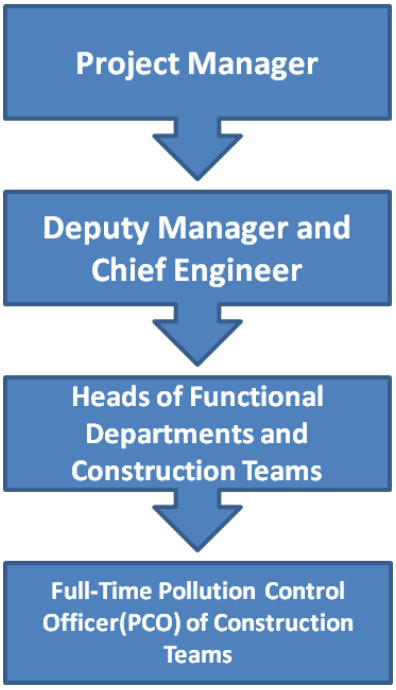


Figure 9-1: Project Environmental Management Organization Chart

Roles and Responsibilities

- The Project manager is diretly responsible with respect to the environmental protection guidelines and the compliance with safeguards and standards required.
- Leaders with specific duties will be responsible for their own specific scope.
- Each construction team and functional department shall conduct well the environmental protection work in their own specific management scope.
- The Contractor in charge of construction and civil engineering works will hire PCO with appropriate experience in the environmental field and fluent in English.
- Pollution Control Officer (PCO) is the direct management department of environmental protection of the Project construction office. The main tasks of the PCO are the following:
    - Responsible for monitoring and management of environmental protection activities.
    - Supervise and urge each department to execute well the environmental protection work.
    - Monitor environmental activities of the Contractor and its sub-contractor
    - Assist in resolution of no-conformance
    - Identify the need for and recommend corrective actions
    - Liaise/coordinate with the PCO from the Project owner regarding Project implementation and compliance activities
    - Prepare a monthly report including (when required) photographic record of implemented environmental protection measures. The monthly report will summarize any relevant special sites investigations and monitoring activities.

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