ENVIRONMENTAL IMPACT STATEMENT REPORT

Proposed Nickel Laterite Mining Project

MPSA 322-2010-XIII SMR

Barangay Pantukan and Adlay, Carrascal, Surigao del Sur
Barangay Cagdianao, Claver, Surigao del Norte

4D VENTURES & DEVELOPMENT INC.
HERNAN CORTES ST. BRGY. TIPOLO MANDAUE CITY, CEBU

Prepared by:

Mediatrix Business Consultancy

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EXECUTIVE SUMMARY

A. PROJECT FACT SHEET

Project Name	Proposed Nickel Laterite Mining Project
Project Location	Barangays Pantukan and Adlay, Carrascal, Surigao del Sur and Barangay Cagdianao, Claver, Surigao del Norte
Project Type	Resource Extraction – Nickel Laterite Mining
Project Area	2,320.0881 hectares (ha) under MPSA 322-2010-XIII SMR issued on February 11, 2010
Project Capacity	5,000,000 Metric Tons (MT) of ore per year
Project Description	4D Ventures and Dev't Inc. (4DVDI) will operate MPSA 322-2010-XIII SMR (Annex ES-1) that involves the extraction and direct shipment of nickel laterite. This MPSA Holder is formerly of North Dinagat Mineral Resources Corporation (NDMRC) but now assigned to 4DVDI. The mining area is located in Barangays Pantukan and Adlay, Carrascal in Surigao del Sur and in Barangay Cagdianao, Claver in Surigao del Norte covering an area of 2,320.0881 has. A Deed of Assignment (Annex ES-2) has been executed with 4D Ventures and Dev't Inc. on September 21, 2020 and has been submitted for registration with the Mines and Geosciences Bureau (MGB) on June 7, 2021. Copies of the Securities and Exchange Commission (SEC) registration of 4DVDI are provided in Annex ES-3. Ore extraction will primary be done through "open cut" method specifically hillslope cutting. It is actually a "cut and fill method" wherein the slope is cut, the overburden is stockpiled near the active, the ore is extracted, and finally the overburden is returned to fill the mined-out area. Bulldozers, backhoes, payloaders, and breakers will be used in the process. Large saprolite ore boulders will be broken into sizes that could facilitate handling and mechanical breakers or people will be used for such activity. Payloading to hauling trucks will follow suit. The ore is eventually hauled to the causeway of Malayan Nickel Mining Corporation wherein an Authority to Use has been issued on Jan. 11, 2022 (Annex ES-4). He ore will be then loaded into a barge or LCT and finally, into the ship to transport it to the processing plant in Mainland China.
Project Components	

Components	Description
Major components	Mining Area / extraction area
	Stockpile area
	Mine Road Network
	Hauling Road Network
Support facilities	Campsite and related facilities
	Assay Laboratory
	Motor pool
	Powerhouse and Power Supply System
	Elevated Tank and Water Distribution System
	Warehouse
	Fuel Storage Facility
	Road Network
	Nursery
	Parking Areas
	Promenade Area
	Stockyard
	Stockpile Areas

		Nursery Extension
		Sampling House
		Pump boat House
		Checker House
		Trapal Men House
		Collector Sump
		Sampling Houses
		Satellite Nursery
	Pollution Control Facilities	Siltation ponds / silt traps / contour settling ponds
		Sabo dam
		MRFs
		Hazardous waste storage area
		Disposal of residual wastes
		Non-hazardous waste storage/lay-down areas
		Oil-water separators
		Septic tanks
Manpower	The Company will employ 500 (295 on Mine Operator side and 205 on Mine Contactor side) employees at the peak of its operation. During the development year (Year 0), the project will initially employ 60 personnel, majority being local skilled. This number will gradually increase over the years.	
Project/Investment Cost	PhP 309,838,841.00	
Profile of the Proponent		
Name of Proponent	4D Ventures and Dev't Inc. thru a Deed of Assignment with North Dinagat Mineral Resources Corporation (NDMRC)	
Address		
Authorized Signatory/ Representative	Mr. Dave Lerio President	
Contact Details	Mobile No.: 0917-8972470 Email address: davelerio@gmail.com	
Profile of the Preparer		
EIA Preparer	Mediatrix Business Consultancy	
Address	L29 Joy-Nostalg Center, 17 ADB Ave., Ortigas Center, Pasig City	
Contact Person	Matilde R. Jimenez-Fernando General Manager	
Contact Details	Telephone No.: (02) 689 7114 Mobile No.: +63917-5064499 Email Address: mediatrixbusinessconsultancy@gmail.com	

B. EIA PROCESS DOCUMENTATION

EIA Team

The EIA Study was conducted by a multidisciplinary team of specialists and consultants of Geo Environmental Consultancy, Inc. (GECI) and Mediatrix Business Consultancy (Mediatrix), in close coordination with 4D Ventures and Dev't Inc. (4DVDI). The Information, Education and Communication (IEC), Public Scoping, Technical Scoping, baseline survey, and impact assessment were carried out by GECI. On the other hand, the revision and updating of the Environmental Impact Statement Report (EISR) were conducted by Mediatrix. The composition of the EIA Team is presented in **Table ES-1**. The sworn statements of accountability of 4DVDI, GECI, and Mediatrix are presented in **Annex ES-5**.

Table ES-1: EIA Team Composition

EIA Team	Areas of Expertise	EMB Registry No.
Mediatrix Business Consultancy		
Matilde J. Fernando	Team Leader, Socio-Economics and Legal Framework	IPCO-035
Fritzie Jane Salido	Water and Air Module	IPCO-114

EIA Team	Areas of Expertise	EMB Registry No.
Ria Caramoan	Air Module	IPCO-106
Xairus De Guzman	Geology Module	IPCO-058
Benjamin Francisco	Freshwater Ecology and Marine Biology	IPCO-038
Mark Angelo Bucay	Terrestrial Ecology	
John Benrich Zuniga		
Alexis Fernando	Field Assignment and Drone Operation	IPCO-034
Juvinal Esteban	IEC and Community Relations	IPCO-091

EIA Schedule

The EIA Study was commenced by conducting Information, Education and Communication (IEC) and Public Scoping activities. Technical Scoping was conducted with the EMB and EIA Review Committee (EIARC) members on February 11, 2016 at the Conference Room of EMB Central Office, DENR Compound, Visayas Ave., Diliman, Quezon City and based on the agreed scope of work, the collection of primary and secondary data was conducted. Data collected were processed, analyzed and evaluated for impact assessment and formulation of Environmental Management Plan (EMP) and Environmental Monitoring Plan (EMoP). The data and information were written into an EISR and the final version of the EISR will be submitted to the EMB-Central Office for ECC application. The major activities undertaken to complete the EIA were listed in **Table ES-2**.

Table ES-2: EIA Study Schedule

Activity	Date
IEC Activities	November 2012, April 2021
Public Scoping	February 5, 2016
Technical Scoping	February 11, 2016
Primary and Secondary Data Gathering	
Geology and Geological Hazards	February – March 2016, April 2021
Pedology	February – March 2016, April 2021
Hydrology/Hydrogeology	February – March 2016, April 2021
Terrestrial Ecology	January 2016, April 2021
Water Quality	January 2016, April 2021
Freshwater and Marine Ecology	January 2016, April 2021
Air Quality and Noise	February – March 2016, January 2018
Perception Survey	February 5-14, 2016, June 2021
Preparation of EISR - revision	March to June 2021
Resubmission of EISR to EMB	July 23, 2021
First EIARC Meeting	February 18, 2022
Public Hearing	April 5, 2022
Second EIARC Meeting	
ECC Issuance	

EIA Study Area

The EIA Study area for the project covers the 2,320.0881 hectares MPSA in Barangays Pantukan and Adlay, Carrascal in Surigao del Sur and in Barangay Cagdianao, Claver in Surigao del Norte. The study area also includes the watersheds hosting the mining operational area; streams draining the mining claim including Marga River, Adlay River, and Kay-ongan River; coastal waters where these rivers drain and causeway site.

EIA Methodology

The EIA for the project conforms to the Revised Procedural Manual for DAO 2003-30 and DAO 2017-15 in the conduct of the following activities, to wit: (i) IEC and Scoping, (ii) collection of primary and secondary data, (iii) identification/prediction/assessment of environmental impacts, (iv) formulation of EMP and the (v) development of EMoP. The baseline information are mainly primary and secondary data which were obtained from the local government units (LGUs) and other government agencies. Data collected were based from the approved EIA Scoping and Screening Form presented in **Annex ES-6**, which was finalized during the Technical Scoping. **Table ES-3** shows the pertinent data, sources, and methodologies used for the conduct of EIA Study.

Table ES-3: EIA Methodology

EIA Study Module	Parameters/Scope	Methodology and Approach on Impact Assessment
Land		
Geology/ Geomorphology, Pedology, Land Use and Classification	Reconnaissance, land use, land classification assessment, slope, soil types and classification, erosion	• Assessment of the compatibility of the project vis-à-vis approved land use plan and zoning classification. • Review of available reports, geologic literature and information from Mines and Geosciences Bureau (MGB), Philippine Institute of Volcanology and Seismology (PHIVOLCS), Philippine Atmospheric, Geophysical and Astronomical Services (PAGASA), and National Mapping and Resource Information Authority (NAMRIA) • Assessment of construction and operation impacts based on the construction and operation activities of the project, and the susceptibility of the project area to natural hazards.
Terrestrial Ecology		• Conduct of field survey using transect, quadrat, and cruising method. • Assessment of impacts based on the construction and operation activities of the project to the existing ecosystem.
Water		
Hydrology/ Hydrogeology	Regional hydrogeology, catchment and drainage system	• Review of existing literatures and maps from DENR and MGB. • Discharge measurement of streams using flotation method. • Computation of monthly streamflow using area discharge ratio method for ungauged streams • Measurement of streams and rivers using curvimeter and topo map • Calculation of water balance • Assessment of impacts based on the construction and operation activities of the project to the existing environment and the susceptibility of the project area to flooding.
Water Quality	Physico-chemical and bacteriological characteristics of freshwater and effluent	• Review of existing water quality monitoring reports. • Sampling and analysis of water • Assessment of impacts based on the construction and operation activities.
Freshwater Ecology	Benthic habitats, species, composition, density, and diversity of sea grass resources and associated macro benthic algae in front of the project site, commercially-important macro invertebrates in the inter-tidal areas, plankton community	• Use of primary and secondary data and interviews • Assessment of impacts based on the construction and operation activities of the project to the existing ecosystem.
Marine Ecology		• Review of existing literatures • Conduct of manta tow, transect, quadrat, visual census, pond net, and sampling • Assessment of impacts based on the construction and operation activities.
Air		
Meteorology/ Climatology	Monthly average rainfall, climatological normal and extremes, wind rose diagrams, and frequency of tropical cyclones	• Assessment of impacts based on the construction and operation activities. • Calculation of GHG emissions using emission factor-based estimation method prescribed in The Greenhouse Gas Protocol, A Corporate Accounting and Reporting Standard, Revised Edition, World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI), 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National GHG Inventories and 2014 IPCC Assessment Report. • Projection of monthly average temperature and rainfall and frequency of extreme events.
Air Quality and Noise Level	Ambient air quality and noise levels	• Review of existing literatures • Conduct of sampling and analysis for PM10, NO2, and SO2

EIA Study Module	Parameters/Scope	Methodology and Approach on Impact Assessment
		• Assessment of impacts based on the construction and operation activities of the project to the existing air quality
People		
Socio-economic and Public health	Morbidity and mortality trends, Demographic data of impact area: - Number of households and household size - Land area - Population - Population density /growth - gender and age profile, - literacy rate, profile of educational attainment Socioeconomic data: Main sources of Income, Employment rate/ profile, sources of livelihood, Poverty incidence, commercial establishments and activities, banking and financial institutions	• Conduct of IEC, Public Scoping, and Perception Survey • Review of CLUP and other secondary data from LGUs and PSA. • Assessment of impacts based on the results of IEC, Public Scoping, perception survey and construction and operation activities of the project.
Environmental Risk Assessment		
Risk Assessment	Safety risks and physical risks	Conduct consequence and Frequency analyses using the methodology described in the Revised Procedural Manual (RPM) for DAO 2003-30

Public Participation Activities

An extensive and comprehensive IEC campaign about the Project and the EIS System was conducted to ensure a meaningful and active participation of well-informed stakeholders – affected residents, host communities, LGUs, relevant agencies, the EMB and the local DENR in the EIA process.

IEC

The IEC was conducted on 03-25 May 2021 to provide updated information about the proposed Project and to encourage the concerned stakeholders to participate in the EIA Study. The IEC was conducted through a provision of IEC materials to the officials and residents of the host municipalities and barangays. IEC materials and photos taken during the IEC are presented in **Annex ES-7**.

Perception Survey

The perception survey was conducted to the host barangays of the project on February 5-14, 2016 and 03-25 May 2021 by 4DVDI thru Mediatrix to cover the respondents in all host barangays. The sample of the perception survey questionnaire is presented in **Annex ES-8** while the results are discussed in the People Module.

Public Scoping

Public Scoping was conducted on February 5, 2016. The Public Scoping was conducted to provide information about the proposed Project and to collect site-specific issues, concerns and inputs to the EIA Study. Consultations were done through Public Scoping and these were attended by barangay officials and residents and LGU Officials. No opposition to the project was raised during the process.

The summary of issues raised during public participation activities is presented in **Table ES-4**. However, the invitation letters, attendance sheets and photos taken during Public Scoping cannot be presented as the former caretaker of documents passed away in year 2020 and no document handover/transfer has been made.

Table ES-4: Summary of Issues Raised during Public Participation Activities

Activity	Issues Raised	Response/Committed Action	Public Perception
IEC	• Boundary issues	Resolution rests with the DILG and the LGUs concerned	Mining in the area is widely accepted by the residents.

Activity	Issues Raised	Response/Committed Action	Public Perception
Public Scoping	• Employment • Dust generation • Siltation and stream discoloration, • Lack proper coordination with LGUs, municipal boundaries • Participation of Indigenous People (IP) during rehabilitation • Protection of watershed of water supply source.	To be included in the EIA Study including the corresponding mitigating measures.	Mining in the area is widely accepted by the residents but wishes the mining would not push through
Perception Survey	• Adverse impacts of the project to air and water quality	Results will be presented in the EISR	Residents perceived mining as a hope to improve their lives.
	• Livelihood	This will be part of the SMDP	

C. EIA SUMMARY

Summary of Alternatives

Ore extraction will primary be done through "open cut" method specifically hillslope cutting. It is actually a "cut and fill method" wherein the slope is cut, the overburden is stockpiled near the active, the ore is extracted, and finally the overburden is returned to fill the mined-out area. Bulldozers, backhoes, payloaders, and breakers will be used in the process. Large saprolite ore boulders will be broken into sizes that could facilitate handling and mechanical breakers or people will be used for such activity. Payloading to hauling trucks will follow suit. The ore is eventually hauled to the causeway and in turn loaded into a barge or LCT and finally, into the ship to transport it to the processing plant in Mainland China. No processing will be done in the project site except to separate the hi-grade ore from the low-grade ore.

Summary of Key Environmental Impacts and Management Plans

Table ES-5 presents the summary of key environmental impacts of the project and the corresponding management plan and mitigating measures.

Table ES-5: Summary of Key Environmental Impacts and Management Plan

Activity per Project Phase	Potential Impacts	Mitigating / Enhancement Measures	Rating/Performance of Mitigating Measures
Construction Phase			
Vegetation Clearing	Reduction of vegetation and fauna disturbance and/or displacement	• Replacement of trees cut as per DMO 05 of 2012 with endemic species combined with fruit bearing trees to be planted at the buffer zone of the MPSA. • Establishment of bamboo plantation following the instruction of the DENR Secretary to establish Bamboo Plantation for the Mining Sector (contractors/ permittees/ permit holders) equivalent to 10% of the declared mined-out areas and 10% of the final mine area.	100% replacement of removed vegetation as per DMO No. 05 of 2012 and DENR Secretary's instruction for a Bamboo Plantation
	Potential siltation of nearby bodies of water due to surface water run-off	• Provision of temporary bunds around the stockpiles of overburden wastes and drainage systems to convey the storm run-off to siltation ponds. • Provision of siltation ponds	100% conveyance of run-off water to siltation ponds
	Air pollution due to generation of dust from site/access road preparation	• Sprinkling of water at least once a day along the access road and project area • Sprinkling of water at least twice a day during hot weather, one in the morning, one in the afternoon	100% compliance with RA 8749
Development of access roads, mining areas, and support facilities	Degradation of surface water quality due to contamination from domestic wastewater	• Provision of Septic Tanks with regular desludging by third party contractor as needed, usually once every two years and two (2) Wastewater Treatment Facility for domestic wastes	100% no discharge of untreated domestic wastewater to nearby bodies of water
	Siltation of surface waters	• Provision of settling ponds as sediment barrier structure • Provision of sediment barrier structure such as silt booms during port construction	100% compliance with RA 9275

Activity per Project Phase	Potential Impacts	Mitigating / Enhancement Measures	Rating/Performance of Mitigating Measures
	Contamination of surface and ground water quality due to accidental oil spill	• Provision of oil residue recovery and reuse system • Implementation of oil spill contingency plan	100% compliance with RA 9275
Operational Phase			
Extraction and hauling of materials and materials transport	Siltation to streams due to erosion of exposed soil and Overburden materials	• Progressive rehabilitation and revegetation of mined out quarries and planting barren lots to prevent soil erosion as per DMO 05 of 2-12 • Utilize the recovered topsoil for re-soiling or as soil cover on waste dumps and other disturbed areas for rehabilitation and revegetation. All stockpiles shall be maintained and managed below the angle of repose of 450. • Continue to implement sediment and erosion control plan • Proper drainage design at the bench toes and access roads, to control the flow of runoff water, and divert it to series of 2 stage siltation ponds (5m. width x 10m. length x 5m. depth = 250 m^3) • Rainwater and runoff collecting systems from crusher flatform shall be provided with primary and secondary silt traps	100% compliance to TSS standards
	Generation of domestic wastewater that may contaminate the soil and receiving body of water	• Provision and proper maintenance of Septic Tanks with regular desludging by third party contractor as needed, usually once every two years and settling ponds for run-off water	100% conformance to DENR effluent standards (RA 9275)
	Generation of solid wastes	• Proper management of domestic solid i.e. provision of Material Recovery Facility for proper waste management and Hazardous Materials Facility (segregation, collection, minimization, reuse, recycle, treatment and disposal	100% compliance to RA9003
	Generation of hazardous wastes from waste oil/ grease and spills from the heavy equipment and vehicles	• Provision of 2,000 liter storage capacity for used oil provided with bund wall • Regular (at least once a year) hauling of hazardous waste by DENR accredited transporter and treater	100% no oil spills and compliance to RA6969
	Generation of fugitive dust during mining operations	• Regular water spraying (minimum once a day, twice a day for hot weathers) of exposed dusty areas during high winds, and dry months. • Establishment of a 20 – meter wide buffer zone planted with different species combination of shrubs, small and medium sized trees around the mine sites such as commercial hardwood tree species such as Gmelina and Santol as well as fruit-bearing trees/ herbs/ shrubs such as Papaya, Mango, Coconut, star apple and santol (endemic) and other endemic species such as but not limited to narra, molave, banaba, mamalis, and bitaog (endemic) as per DMO 05 od 2012.	100% no dust be seen in the area

1. PROJECT DESCRIPTION

4DVDI proposed to operate a mining project that involves the extraction and direct shipment of nickel laterite from a Mineral Production Sharing Agreement (MPSA) permitted area formerly owned by NDMRC as MPSA Holder located in Barangays Pantukan and Adlay, Carrascal in Surigao del Sur and in Barangay Cagdianao, Claver in Surigao del Norte. Denominated as MPSA 322-2010-XIII SMR, the mining claim covers an area of 1,352.38571 hectares (ha) although only a portion of this will be subjected to extraction.

On September 21, 2020, a Deed of Assignment (DOA) has been executed with 4D Ventures and Dev't Inc. (4DVDI) and has been submitted for registration with the Mines and Geosciences Bureau (MGB) on June 7, 2021.

NDMRC's office is located at Unit 2106A East Tektite Tower, Philippine Stock Exchange Center, Ortigas, Pasig City while 4DVDI's office is located in Ground Floor Nadiesheko Bldg., 6014 Mandaue City, Cebu – Philippines.

1.1 PROJECT LOCATION AND AREA

1.1.1 Description of the Project Area

The proposed Project with a total area of 2,320.0881 has is under the MPSA No. 322-2010-XIII, was entered into by and between the Government and NDMRC on February 11, 2010 covering portion of the areas of Barangays Pantukan and Adlay, Carrascal in Surigao del Sur and Barangay Cagdianao, Claver in Surigao del Norte. The campsite, causeway, and part of the hauling road are located in Barangay Adlay, Carrascal, Surigao del Sur.

The MPSA is surrounded by the MPSA of Platinum Group of Minerals Corp., by the MPSA of CTP Construction and Mining Corp, Carac-an Watershed Reservation, and by MPSA of Ludguron Mining Corp. and Kafugan Mining, Inc. The 2,320.0881 has project site is situated within the Mineral Land Reservation declared through Presidential Proclamation No, 391 series of 1939 during the term of President Manuel L. Quezon.

Accessibility

From Manila, Surigao City can be access via plane operated by Philippine Air Lines and Cebu Pacific Airline. When not using a private car, the mine site can be reached from Surigao City Airport through regular trips of Bachelor Bus Lines and special trips of passenger vans stationed at the airport.

Tables 1.1.1 to 1.1.4 present the geographic coordinates of the project site. **Figures 1.1.1** to **1.1.4** present the location map of the project site.

Table 1.1.1: Coordinates of the MPSA Area

Point	Coordinates	
	Latitude	Longitude
1	9°24'01.34"N	125°50'15.00"E
2	9°27'00.00"N	125°50'15.00"E
3	9°27'00.00"N	125°51'30.00"E
4	9°23'18.77"N	125°51'30.00"E
5	9°23'26.17"N	125°51'20.82"E
6	9°23'39.02"N	125°51'14.69"E
7	9°23'50.83"N	125°51'03.45"E
8	9°23'49.16"N	125°50'41.92"E
9	9°23'57.84"N	125°50'28.73"E
10	9°24'01.34"	125°50'15.00"

Table 1.1.2: Coordinates of the Causeway Areas

POINT	NORTHING	EASTING
1	1044436.492	820854.027
2	1044506.812	820812.921
3	1044524.646	820838.24
4	1044511.995	820846.806
5	1044555.839	820914.605
6	1044514.283	820941.209
7	1044436.492	820854.027

Table 1.1.3: Coordinates of the Stockyard Area

POINT	NORTHING	EASTING
1	1044177.213	819831.198
2	1044431.132	819712.734
3	1044880.624	819980.296
4	1044772.978	820259.828
5	1044411.906	820049.603
6	1044161.604	820006.55
7	1044177.213	819831.198

Table 1.1.4: Coordinates of the Nursery Area

POINT	NORTHING	EASTING
1	1044891.136	819239.341
2	1044877.037	818763.666
3	1044597.997	818798.196
4	1044759.778	819295.665
5	1044891.136	819239.341

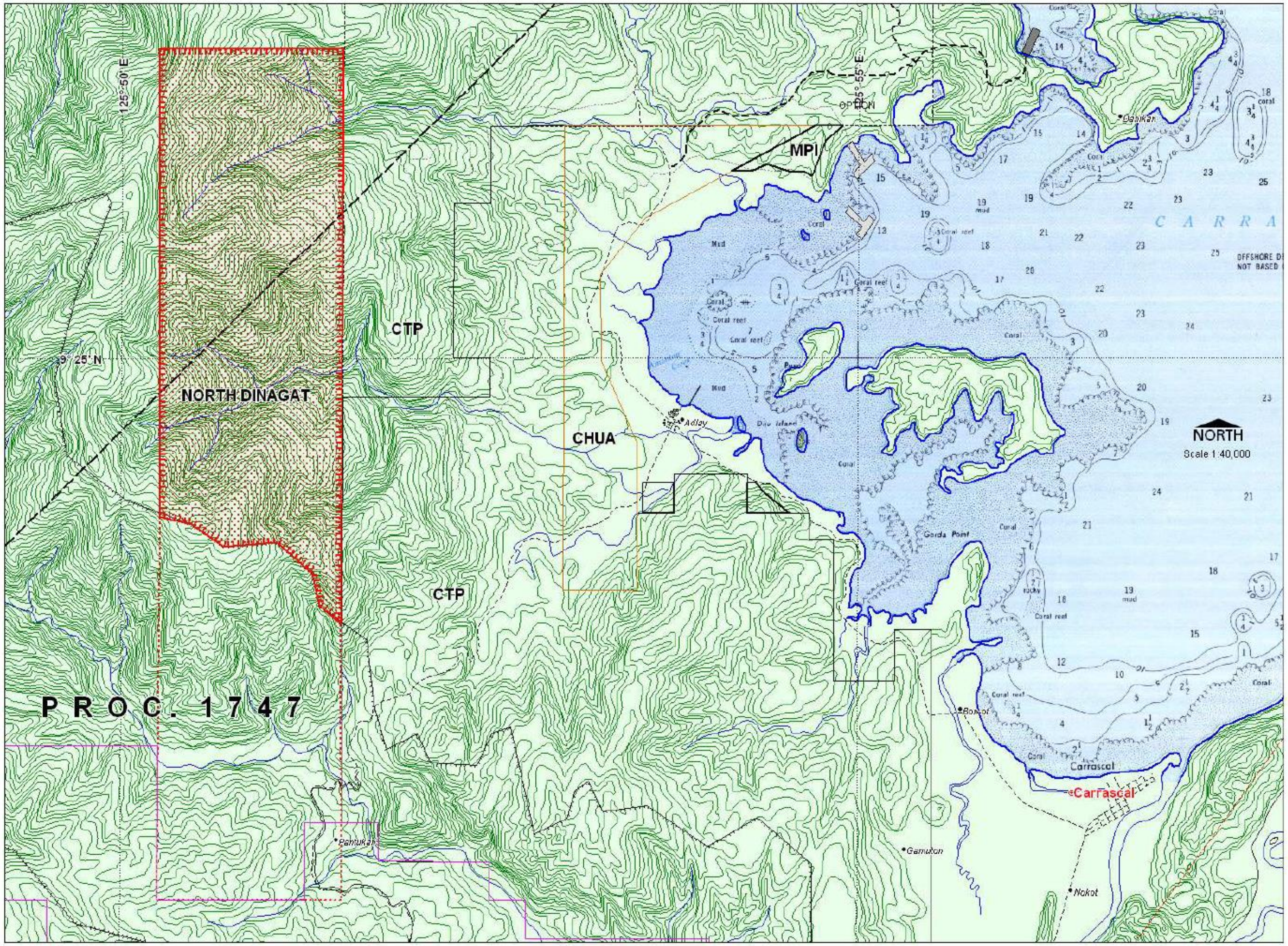

Figure 1.1.1: Geographical Location of the MPSA Area

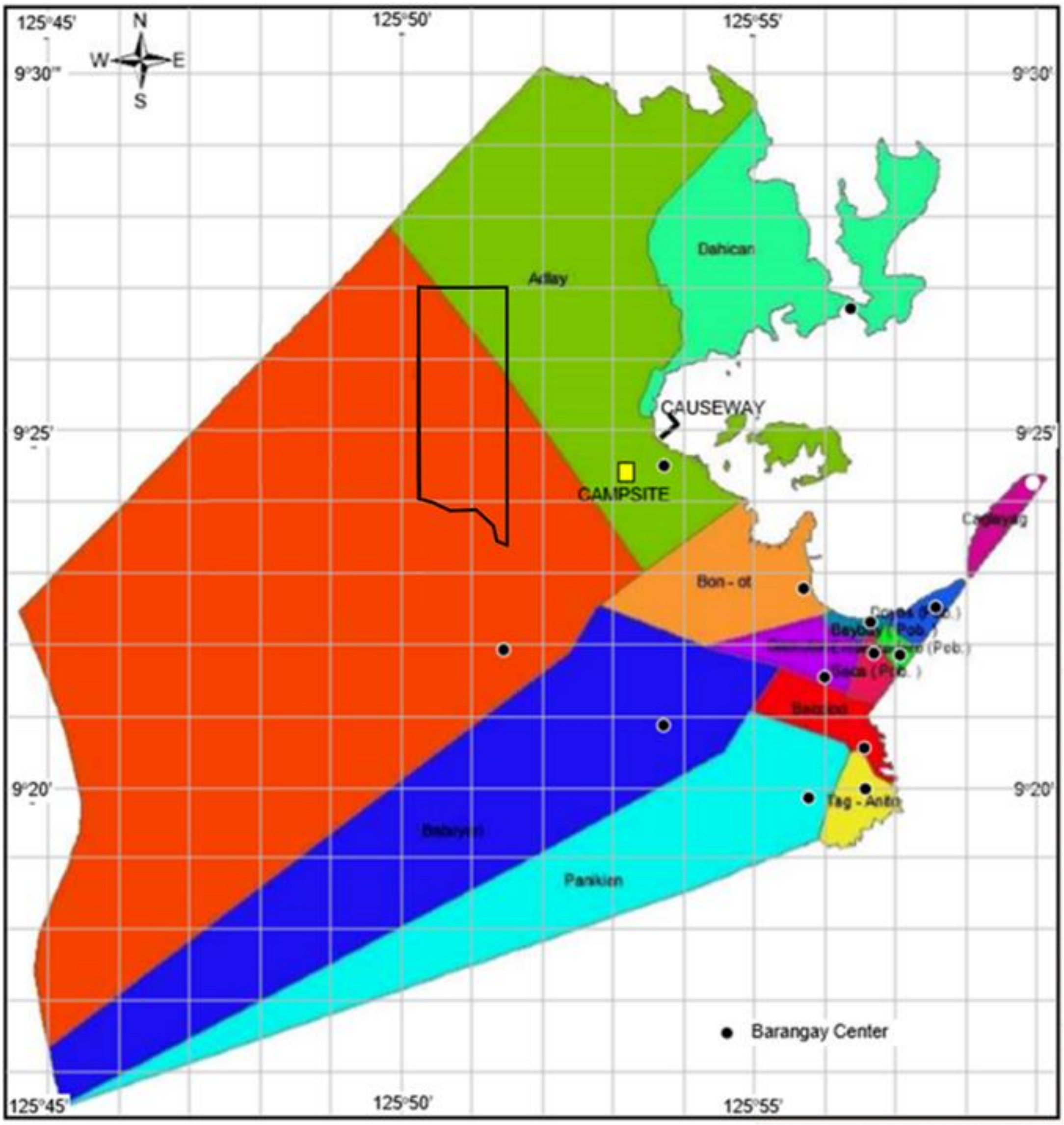

Figure 1.1.2: The Project Site Plotted on the Municipal Map of Carrascal, Surrigao del Sur

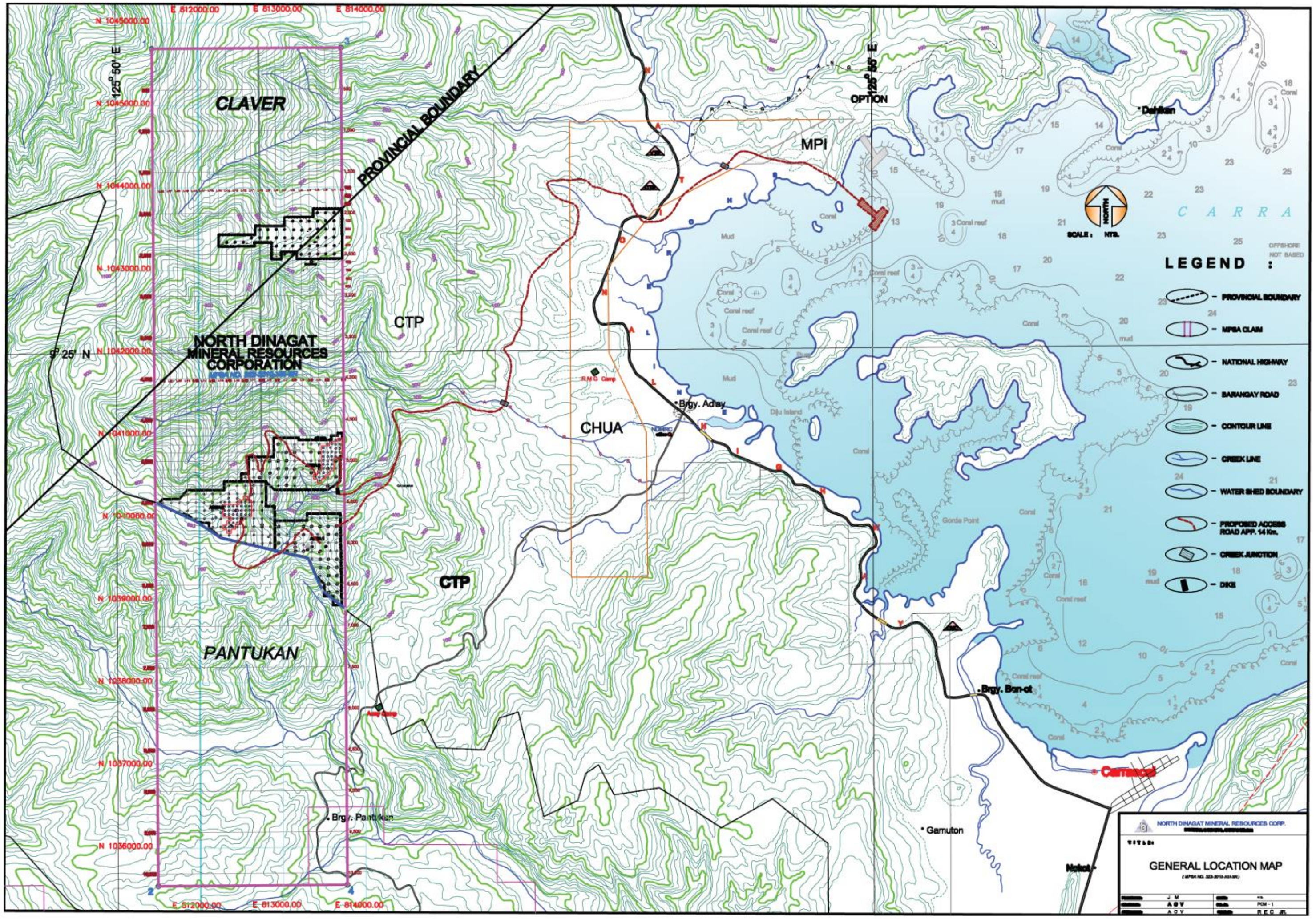

Figure 1.1.3:MPSA Area Relative to the Surrounding Mining Properties

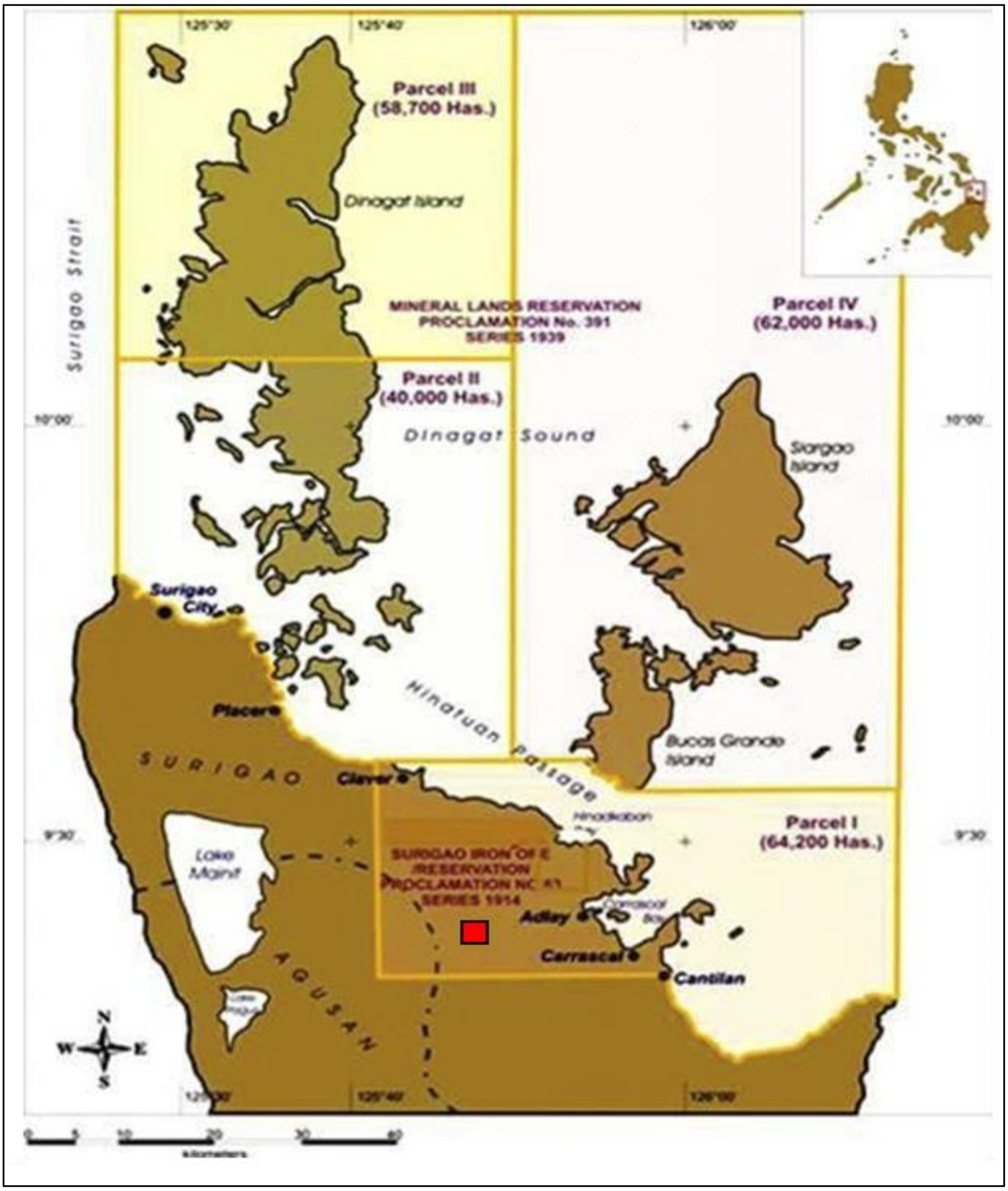

Figure 1.1.4: Mineral Land Reservation – Parcel 1 where the Proposed Project is Located

1.1.2 Impact Areas

The direct impact areas (DIA) are those directly affected by the extraction and hauling of ore from the 2,320.0881 has project site to the causeway and the causeway itself. In the extraction of ore, the areas to be affected are the different areas where mining is being done. The hauling route is considered direct impact zone primarily because of dust generation.

Impacts considered in the delineation of the direct impact zones are dust generation, mass wasting processes, accelerated and excessive erosion, siltation at the upper reaches of the natural drainages, loss of groundwater recharge, soil removal, generation of mining waste, removal of vegetation, displacement of terrestrial fauna, deterioration of surface and groundwater water quality, increased amount of NOx and SOx at the extraction area and hauling routes, increased in health risk from inhalation of dust that may contain asbestos at the extraction and hauling areas and noise generation.

The indirect impact areas (IIA) are those affected by siltation or turbidity in creek waters and include the downstream segments of all streams emanating from the extraction areas. The tidal flat and the coastal waters fronting these creeks and the causeway are classified under the indirect impact areas due to the siltation and murky waters expected to affect these areas, respectively.

The impacts considered under this classification are siltation at the lower reaches of all streams coming from active mining areas, siltation of tidal flats, deterioration of the quality of surface and coastal waters, damage to some marine ecosystems, and increased amount of NO_x and SO_x along the highway, resource competition between local folks and migrant workers, increased in health risk from inhalation dust along the highway, non assimilation of diverse culture, and proliferation of vices.

The map of impact areas is shown in **Figure 1.1.5**.

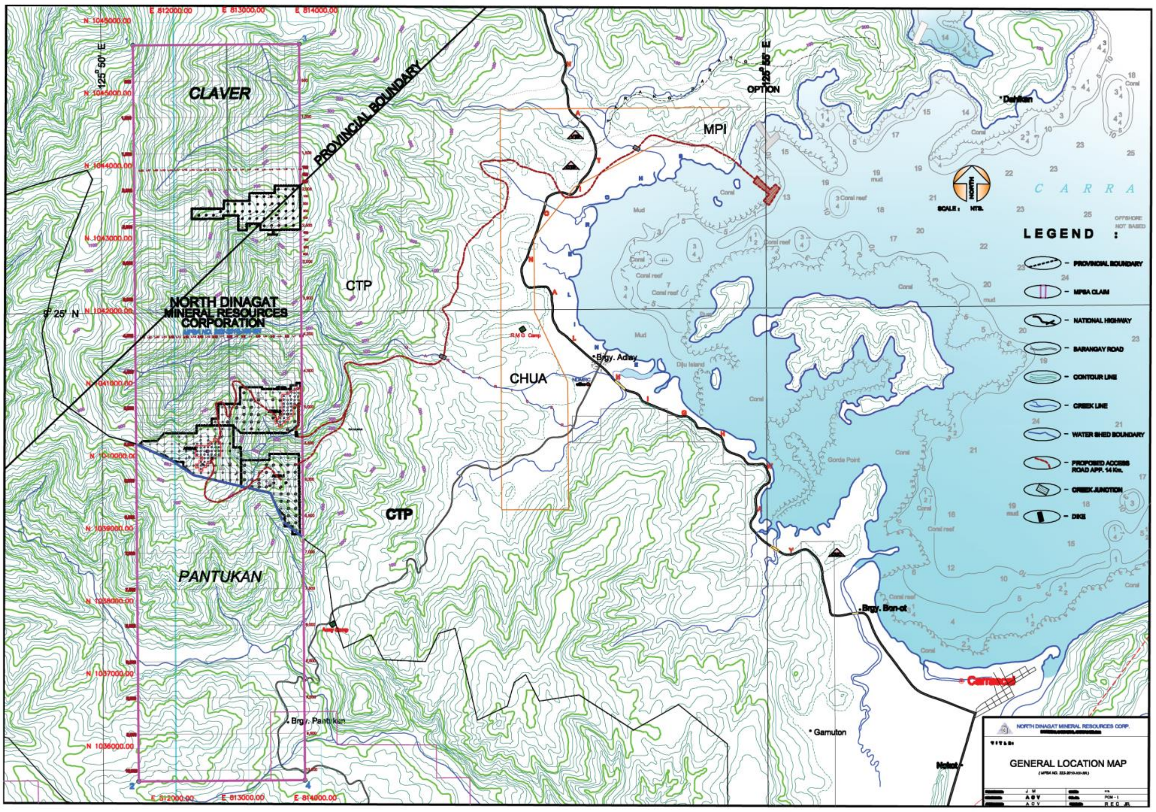

Figure 1.1.5: Impact Areas of the Project

1.2 PROJECT RATIONALE

More than a decade ago, the mining industry had suffered from major loses and left in the doldrums with no bright future in sight. The metal mining sector in this country had been forgotten despite emblazoning the name Philippines on the world's mining map while the industry was still on its peak. It suffered major setbacks, so huge that resurrecting the industry became a gargantuan task. Many mining companies closed shop. Then came the Philippine Mining Act of 1995. In the early goings, it presented a glimmer of hope and spurred interest in the mining industry but issues like environmental protection, low meta prices in the international market, radical opposition to mining, political interferences, and concerns over the indigenous people's rights dampen the foreign investors' enthusiasm. The Philippines therefore lost its chance to resurrect the economy by utilizing the mineral resources the country is known for. These resources are just around the corner waiting to be tapped and marketed. Utilizing them can prosper economic growth not only in the local but in the national level as well.

The environmental issues are now properly addressed although still wanting, the concerns for the indigenous people's rights are likewise put in their proper perspectives, and the prices of metals in the world market had gone wild increasing by leaps and bounds. Now, the country's economy is slowly awakening and the company management wishes to contribute in its own little way solidifying the newly-found vigor and investing in mining projects would be a significant contribution.

However, the metal prices have again dipped to survival levels and already affecting even the big mining companies. If this trend continues, the mining companies will have no recourse but to temporarily stop. Recently, some metals recovered including nickel and this will sustain continued production even by small companies. Still a promising economic growth stimulant.

1.3 PROJECT ALTERNATIVES

1.3.1 Site and Technology Selection

There was no other alternative site considered for this mining project because the project site already has an MPSA.

In the case of siting the facilities such as those in the campsite and the causeway including stockpile and fuel storage, there were some alternatives considered but due to major irreversible conflicts in access to the sea, this was rejected.

4DVDI will use an existing causeway and will not build a new one. The selection of the existing Nasipit area for both campsite and causeway were made with special considerations for geohazards, technical, commercial, social, and environmental factors.

For geohazards, ground materials are not liquefiable, seismic – PGA is only 0.32 g, tsunamis would be light id there will be, shielded by island from typhoons, seas are not very rough whole year round, no nearby active volcanoes, flooding is not expected because the site is elevated, and no landslide is expected because the topography is flat. The site is accessible from anywhere as there are road networks that can be used form all directions. Fuel storage can also be erected at safe distance from the causeway and still accessible. The topography is gently sloping which is good for the campsite thus promoting smooth and faster stockpiling and loading operations.

The causeway site is far from communities that might be affected by the operations. Lastly, the environmental impacts of the causeway operations can be adequately mitigated because environmental management and monitoring measures will be in place.

1.3.2 No Project Option

Not continuing with the project is not an option. If the project will not continue, the additional employment opportunities for qualified residents of the host barangays and other barangays in Carrascal and Claver as well as the social development for the community such as livelihood projects, skills training, scholarship programs and medical assistance will be lost. Also, the substantial increase in local taxes and revenues, multiplier effect of the project such as business opportunities, support to social services and other opportunities for the community and the local government unit (LGU) will also be foregone.

The possibility of expanding and upgrading LGU's basic infrastructure services and facilities and strengthening of LGU's capacity in city governance, investment planning, revenue generation and project development and implementation will not also be realized. This may also include possibility of enhancing their capabilities for local leadership because the project may provide technical support and assistance to local leaders to training, seminars and workshops. All of these may be provided by the project thru its tax payments, permits and clearances and Social Development Program.

1.4 PROJECT COMPONENTS

The components of the proposed project include the Mining Area, Causeway Area, Campsite Area, and Stockyard Area. **Table 1.4.1** presents the major components, support facilities, and pollution control devices of the proposed project.

The operation of the proposed project does not involve metallurgical or chemical processing. There is a semblance of beneficiation though by manually sorting hard rock ore and crushing them mechanically for easy handling.

Table 1.4.1: Project Components of the Proposed Project

Item	Number	Ares (ha)
Main Component		
Mining Areas:		
Extraction Area	Multiple	300
Sabo Dams	Multiple	
Siltation Ponds	Multiple	
Contour Settling Canals	4	
Perimeter Canals	2	
Sampling Houses	4	
Satellite Nursery	2	
Mine Road Network	1	
Hauling Road Network	1	
Causeway Area:		
Berthing Areas	6	
Fuel Storage Facility	1	
Sampling House	1	
Pump boat House	1	
Checker House	1	
Trapal Men House	1	
Collector Sump	3	
Wooden Jetty	1	
Causeway	2	
Wooden Jetty	1	
Ballast Stockpile Area	1	
Support Facilities		
Campsite Area:		10
Administrative Office	1	
Staff houses	2	
Guesthouse	1	
Mess Hall	1	
Clinic	1	
Assay Laboratory	1	
Motor pool	1	
Outdoor Sports Facility	1	
Powerhouse and Power Supply System	1	
Elevated Tank and Water Distribution System	1	
Warehouse	1	
Road Network	1	
Nursery	1	
Guardhouse	1	
Parking Areas	3	

Item	Number	Ares (ha)
Stockyard Area:		4
Stockpile Areas	2	
Equipment Parking Area	2	
Guardhouse	1	
Nursery Extension	1	
Pollution Control Facilities		
MRFs		
Hazardous waste storage area		
Disposal of residual wastes		
Non-hazardous waste storage/lay-down areas		
Oil-water separators		
Septic tanks		

Note: Dimensions are subject to change.

1.4.1 Major Components

1.4.1.1 Mining Area

The mining area includes the extraction area, sabo dams, siltation ponds, contour settling canals, perimeter canals, sampling houses, satellite nursery, mine road network, and hauling road network.

1.4.1.2 Causeway Area

A causeway is one of the most important components of the mining operation. It is a transit point that transforms the mode of transportation from land to sea. Since the ore will be transported overseas, it functions as a transfer station from the hauling of ore over land and the eventual shipment to foreign land after travelling across oceans. Here, ore is loaded into barges that deliver it to ships.

1.4.2 Support Facilities

1.4.2.1 Campsite Area

The campsite is the central headquarters of the mining operations. It will cover an area of 10-15ha and will house several vertical and horizontal structures that include the administrative office, staff houses, guesthouse, mess hall, laboratory, indoor sports facility, fuel storage facility, warehouse, motor pool, parking areas, outdoor sports facilities, a promenade park, nursery and others.

1.4.2.2 Stockyard Area

The stockyard will be sited near the campsite and will cover an area of 72 ha to contain large amount of ore that will be segregated according to grade or generic classification.

4DVDI plans to establish at least two (2) major nurseries, one (1) in the Campsite and Stockyard and the other at the initial extraction area. Satellite nurseries will also be set up as mining operations progress. The two (2) nurseries will have a minimum dimension of 100 x 100 meters each and has provisions for expansion to meet the demands of full-scale rehabilitation as mining progresses in fast pace. Preferred seedlings will be coming from endemic and edaphic species but imports that are fast-growing and nitrogen-fixing will also be introduced examples of which are mangium and other species of pine trees. Number of seedlings will be sustained to meet the need of rehabilitating the mined-out areas and those that had been committed for the National Greening Program.

1.4.3 Pollution Control Devices

Foremost are the siltation and discoloration control devices that includes mining benches to minimize soil erosion, perimeter canals to collect runoff from the active mining areas, sabo dams across gullies draining the extraction areas, siltation ponds with flocculation cell downstream of gullies, and silt traps along roads. Others include materials recovery facility (MRF) for solid wastes, color-coded trash bins, temporary storage areas for solid and hazardous wastes, 3-chambered septic tanks for domestic wastes, mufflers for heavy equipment and vehicles, and water spraying tankers for dusts.

Actual maintenance of the siltation/discoloration control structures will be supervised by the MEPEO with the equipment and personnel provided by the Engineering Department. The structures will be monitored by MEPEO during the wet seasons and rain events. Dust and noise control will be handled by MEPEO with tankers and personnel at its direct supervision. For solid wastes, monitoring and maintenance will also be done by MEPEO. The same is true with the effluent management.

1.4.4 General Layout of Facilities

Figures 1.4.1 to **1.4.4** present the Development Plans for the proposed project.

It may be seen from the map that the haul road and causeway are outside the MPSA area. These are within private land where an agreement/s is/are currently being secured. Provided below is the tabulated area for the support facilities:

Table 1.4.4.1: Tabulated area for the support facilities

Support Facility	Area (in hectares)
Road network / haul road	12 km from MPSA Boundary up to Parang-Parang Pier
Causeway	with separate ECC under CTP Construction and Mining Corporation
Stockpile area	20
Motorpool	10
Campsite and related facilities	10

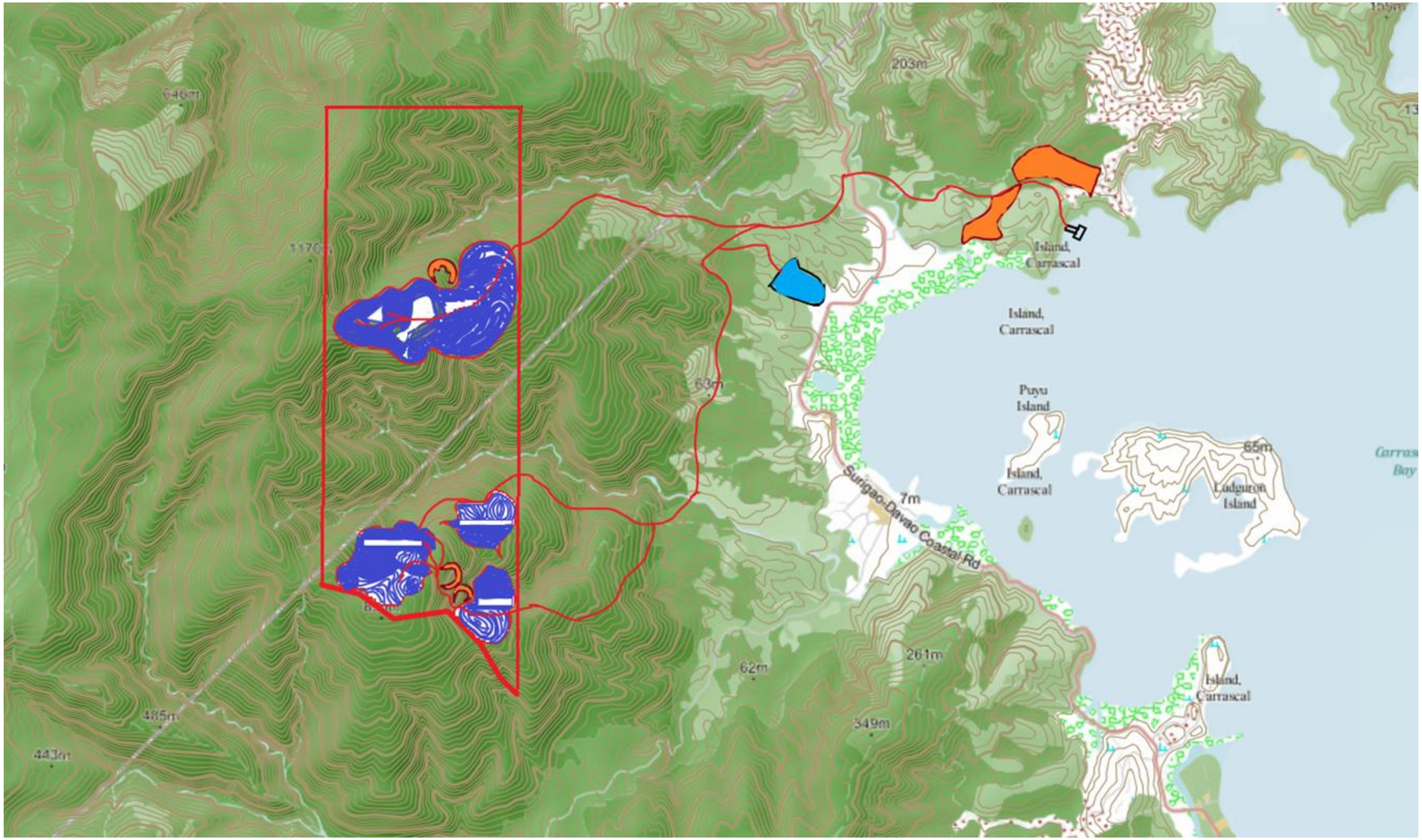

Figure 1.4.1: Mining Development Plan in Area 1

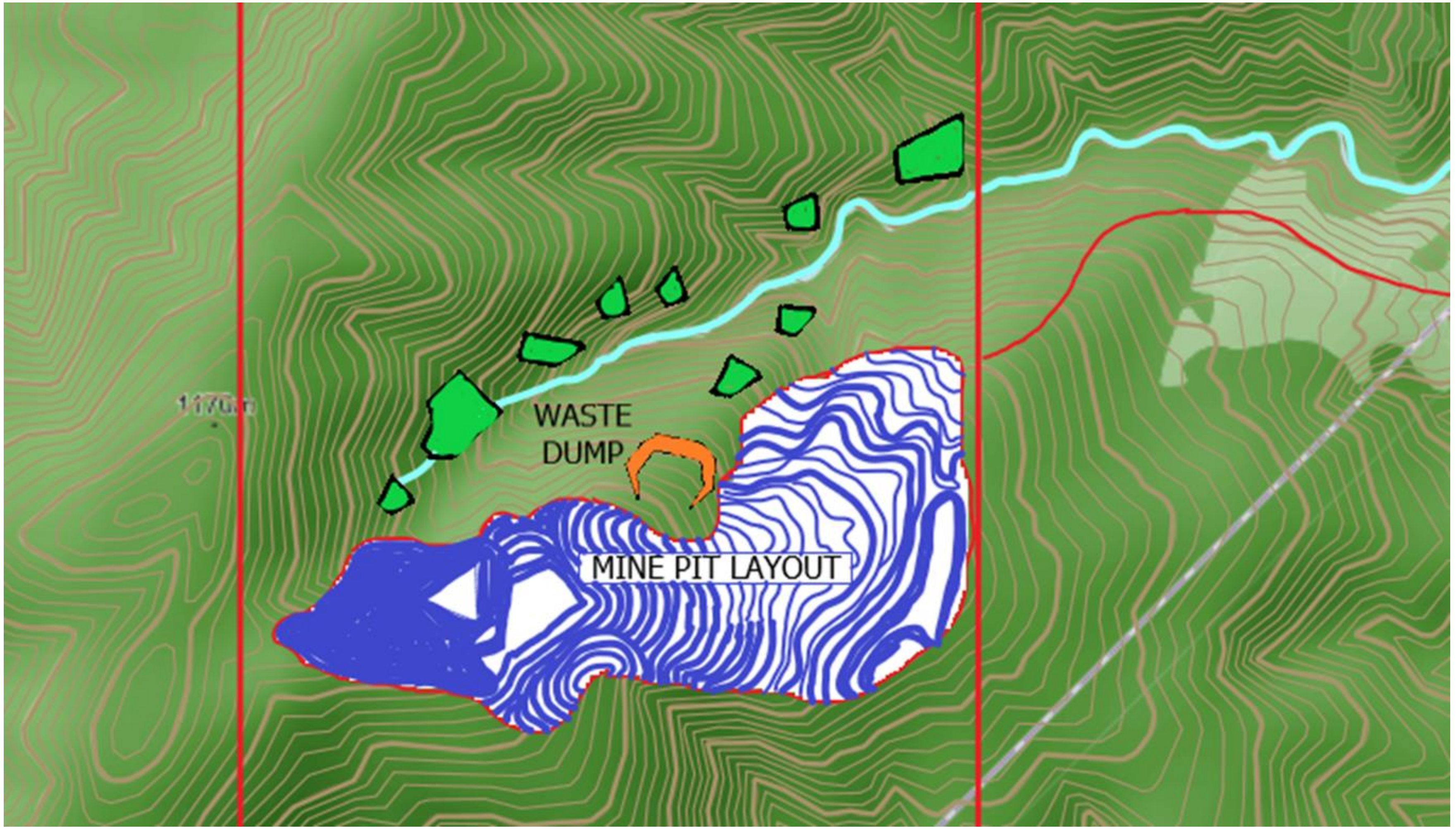

Figure 1.4.2: Mining Development Plan in Area 2

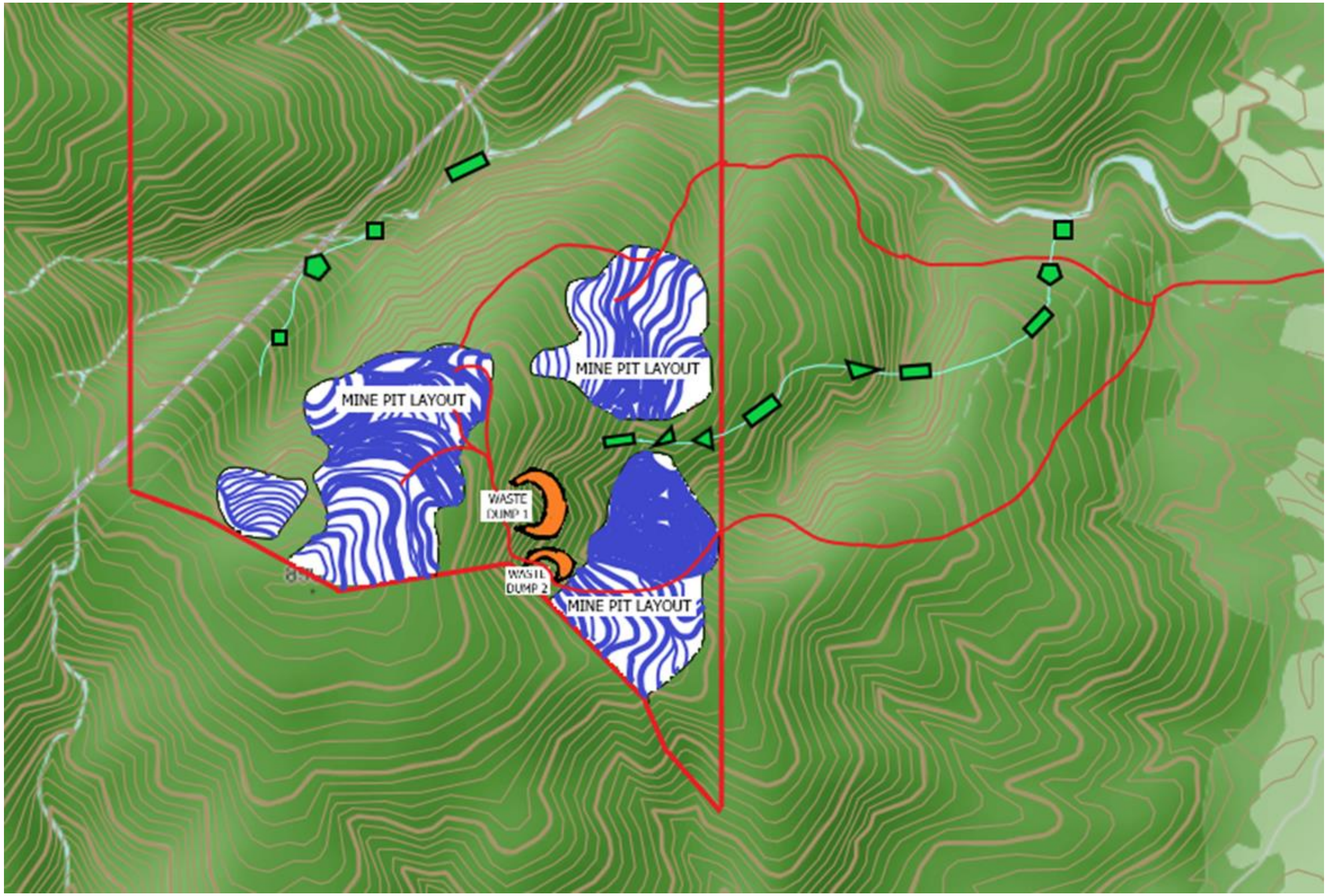

Figure 1.4.3: Development Plan in Area 4

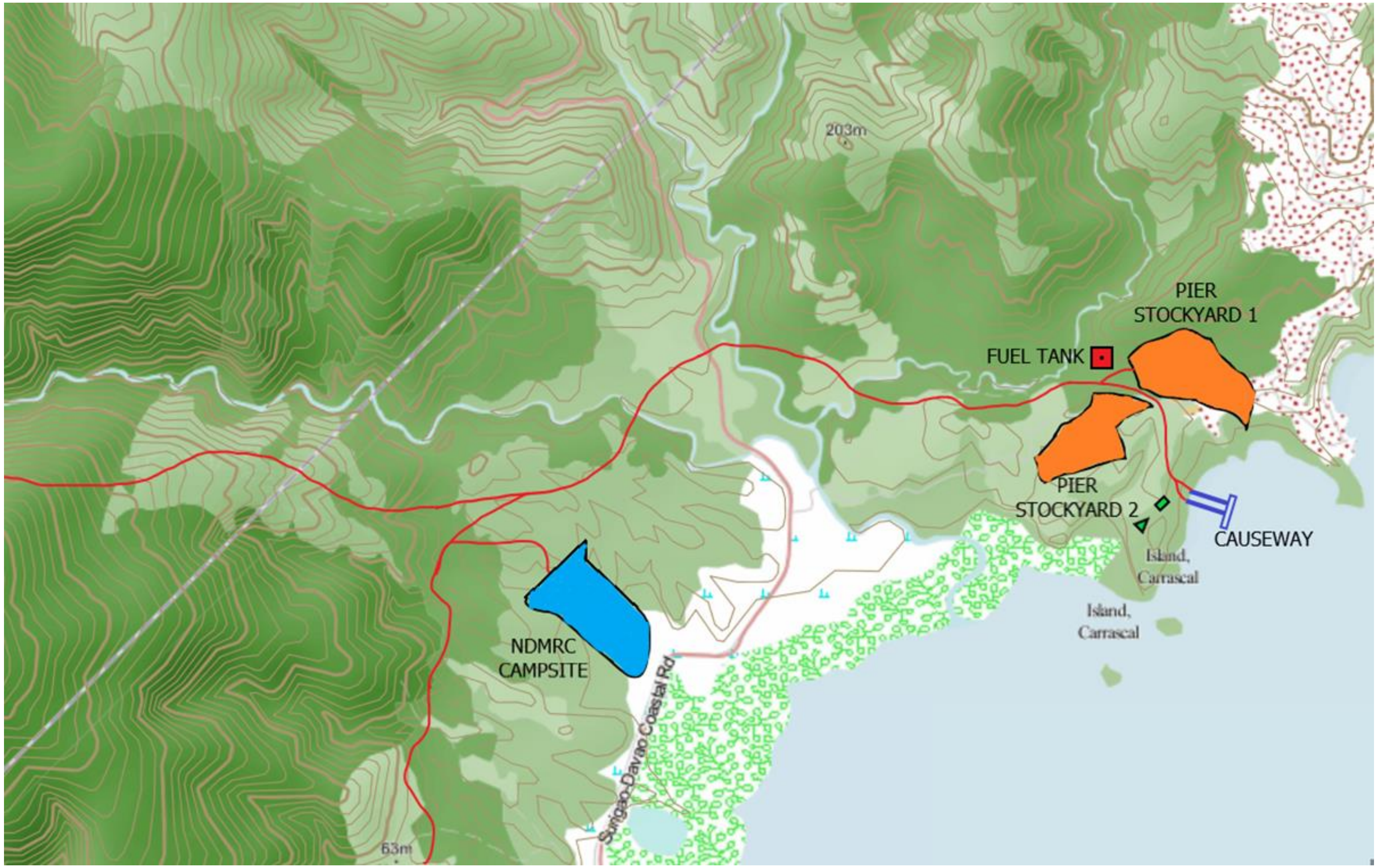

Figure 1.4.4: Campsite, Hauling Road, Stockyard and Causeway

1.5 PROCESS /TECHNOLOGY

1.5.1 Mining Process/Technology

Ore extraction will primary be done through "open cut" method specifically hillslope cutting. It is actually a "cut and fill method" wherein the slope is cut, the overburden is stockpiled near the active, the ore is extracted, and finally the overburden is returned to fill the mined-out area. Bulldozers, backhoes, payloaders, and breakers will be used in the process. Large saprolite ore boulders will be broken into sizes that could facilitate handling and mechanical breakers or people will be used for such activity. Payloading to hauling trucks will follow suit. The ore is eventually hauled to the causeway and in turn loaded into a barge or LCT and finally, into the ship to transport it to the processing plant in Mainland China. The operation does not involve metallurgical processing. There is a semblance of beneficiation by manually sorting hard rock ore and crushing them mechanically for easily handling.

1.5.2 Operations and Maintenance of Facility

Operations and maintenance of facility are not applicable except for operations and maintenance of mining equipment and the hauling and access roads.

Proper maintenance of mining equipment shall be required from the contractors to ensure its safety and worthiness in its operations. The hauling and access roads shall be maintained by 4DVDI. To do this, water sprinkling and other dust and mud management shall be undertaken.

1.5.3 Utility Requirements

1.5.3.1 Power Supply

The power requirement of the project will be source from SURSECO II but 4DVDI will provide stand-by generators in areas that require them. It is important to note that no operation will be done during the night.

1.5.3.2 Water Supply

Water will be sourced from the surface water using PVC pipes to supply the camp through gravity. An overhead tank will be constructed at the campsite. The water supply system shall be able to deliver at least 100 m3 daily to the camp. Groundwater sourcing will also be looked into especially that surface water becomes turbid during rain events and dries up in summer.

1.5.4 Waste Generation and Built-in Management Measures

Disposal procedures of hazardous, solid and domestic wastes are as follows:

- Used oil will be collected and put inside sealed drums, stored in a company designated MRF inside the plant. It will be transported and treated by a DENR accredited TSD facility.
- Busted Fluorescent Bulbs will be put in a container, stored inside the plant MRF in accumulation until there are sufficient inventory for proper disposal through a DENR accredited TSD facility.
- Contaminated rags and gloves will also be put in bags, stored inside the plant MRF in Accumulation until there is sufficient inventory for proper disposal through a DENR accredited TSD facility.
- Used automotive batteries will be traded-in to designated suppliers.
- Solid Wastes will be properly segregated and to be disposed in the MRF of Carrascal and Claver.
- Domestic Waste will be treated through the proposed Sewerage Treatment Plant.
- Industrial wastewater: this water treatment system guarantees zero discharge of industrial wastewater.

1.6 PROJECT SIZE

The mining operation is confined within the 2,320.0881 has area of MPSA 322-2010-XIII-SMR intending to produce 5,000,000 wet metric tons (WMT) of ore annually (**Table 1.6.1**). Even if based on the ore's average specific gravity of 1.63, the yearly production is equivalent to 3,067,484 m^3, the exploration is still ongoing to convert the inferred and indicated resources to measured.

Table 1.6.1: Project Capacity

Material Movement Type	UOM	Year 1	Year 2	Year 3	Year 4
1. Ore Production					
1.1 Limonite	WMT	3,130,000	3,140,000	3,210,000	3,190,000
1.2 Saprolite	WMT	1,870,000	1,860,000	1,790,000	1,810,000
1.3 Total Annual Ore Production	WMT	5,000,000	5,000,000	5,000,000	5,000,000
2. Waste Handling					
2.1 Overburden	WMT	77,000	77,000	75,900	77,000
2.2 Saprolite Boulder	WMT	187,000	186,000	179,000	181,000
2.3 Total Annual Waste Handle	WMT	264,000	263,000	254,900	258,000
3. Shipment					
3.1 Limonite	WMT	3,080,000	3,190,000	3,190,000	3,190,000
3.2 Saprolite	WMT	1,870,000	1,815,000	1,815,000	1,815,000
3.3 Total Annual Shipment	WMT	4,950,000	5,005,000	5,005,000	5,005,000
4. Total Annual Material Movement	**WMT**	**10,214,000**	**10,268,000**	**10,259,900**	**10,263,000**
Material Movement Type	**UOM**	**Year 5**	**Year 6**	**Year 7**	**Year 8**
1. Ore Production					
1.1 Limonite	WMT	3,100,000	2,650,000	2,650,000	3,050,000
1.2 Saprolite	WMT	1,900,000	2,350,000	2,350,000	1,950,000
1.3 Total Annual Ore Production	WMT	5,000,000	5,000,000	5,000,000	5,000,000
2. Waste Handling					
2.1 Overburden	WMT	77,000	77,000	75,900	77,000
2.2 Saprolite Boulder	WMT	190,000	235,000	235,000	195,000
2.3 Total Annual Waste Handle	WMT	267,000	312,000	310,900	272,000
3. Shipment					
3.1 Limonite	WMT	3,080,000	2,695,000	2,640,000	3,025,000
3.2 Saprolite	WMT	1,870,000	2,365,000	2,310,000	1,980,000
3.3 Total Annual Shipment	WMT	4,950,000	5,060,000	4,950,000	5,005,000
4. Total Annual Material Movement	**WMT**	**10,217,000**	**10,372,000**	**10,260,900**	**10,277,000**
Material Movement Type	**UOM**	**Year 9**	**Year 10**	**Year 11**	**Total**
1. Ore Production					
1.1 Limonite	WMT	3,120,000	2,900,000	2,920,000	**26,820,000**
1.2 Saprolite	WMT	1,880,000	2,100,000	2,080,000	**18,180,000**
1.3 Total Annual Ore Production	WMT	5,000,000	5,000,000	5,000,000	**45,000,000**
2. Waste Handling					
2.1 Overburden	WMT	75,900	69,300	66,000	**671,000**
2.2 Saprolite Boulder	WMT	188,000	210,000	208,000	**1,818,000**
2.3 Total Annual Waste Handle	WMT	263,900	279,300	274,000	**2,489,000**
3. Shipment					
3.1 Limonite	WMT	3,135,000	2,860,000	2,970,000	**26,840,000**
3.2 Saprolite	WMT	1,870,000	2,090,000	2,090,000	**18,095,000**
3.3 Total Annual Shipment	WMT	5,005,000	4,950,000	5,060,000	**44,935,000**
4. Total Annual Material Movement	**WMT**	**10,268,900**	**10,229,300**	**10,334,000**	**92,424,000**

Table 1.6.2: Production schedule in conformance to the DAO limiting extraction area at any one time based on mine production

Year	Tonnage	Active Area for Extraction at any Given Time
Year 1	1,500,000	60
Year 2	3,000,000	70
Year 3	3,000,000	70
Year 4	3,000,000	70
Year 5	4,000,000	70
Year 6	4,000,000	70
Year 7	5,000,000	80
Year 8	5,000,000	80
Year 9	5,000,000	80
Year 10	5,000,000	80
Year 11	6,000,000	80
Year 12	6,000,000	80
Total	**50,500,000**	

1.7 DEVELOPMENT PLAN, DESCRIPTION OF PROJECT PHASES AND CORRESPONDING TIMEFRAMES

1.7.1 Project Phases

The project has four (4) phases namely pre-development phase, development phase, operational phase, and abandonment phase. **Table 1.7.1** presents the major activities, associated wastes, key environmental and social issues, and environmental management measures. Built-in Pollution Control Measures are those that are inherent to the development/construction, operations, and abandonment of the mine.

Table 1.7.1: Tabulated description of major activities and key environmental issues in the Different Project Phases

Activity	Associated Wastes	Key Environmental Issues	Pollution Control Measures
Development or Construction Phase			
Construction of causeway and access road from highway to the causeway	Solid wastes (plant cuttings) Excess soil	Loss of mangrove. Dispersion of suspended solids.	Proper disposal of SW. Use of silt curtain to control dispersion.
Construction of hauling and access roads highway to mining area	Solid wastes (plant cuttings)	Dust Generation Stream	Water spraying of road
Construction of campsite structures and preparation of stockyard	Construction debris, domestic wastes	Solid waste generation	Segregation at source. Proper disposal of residuals
Clearing of areas programmed for extraction	Overburden and plant remains	Solid waste generation	Save the soil and plant remains in waste dump.
Operations Phase			
Extraction of ore, rehabilitation of mined-out areas,	Soil, plant remains Loose soil	Excessive erosion, Siltation of nearby stream coastal areas water quality deterioration, loss of water supply	Prevent erosion through soil compaction and cover. Control overland flow and runoff. Integrate protection measures like contour ditches, sabo dams, siltation ponds and flocculation
Hauling of ore from mining area to stockpile area and from there, to the causeway	Suspended Solids, NOx and SOx Noise	Health hazard, nuisance	Muffler for noise. Regularly spray the road to prevent lifting of dust. Keep equipment in tip-top shape.

1.7.1.1 Pre-Development/Construction Phase

This phase is dedicated mostly to activities like geological exploration, mining rights acquisition, procurement of permits and clearances from concerned government agencies and local government units and bidding out of civil works that will be undertaken during the development stage.

1.7.1.1.1 Geological Exploration

1.7.1.1.1.1 Site Geology

Serpentinized ultramafic rocks, a member of the Dinagat Ophiolite Complex (DOC) exclusively underlies the entire tenement and the eastern portion of the mapped area (**Figure 1.7.1**). The ultramafic rocks are primarily classified as is usually serpentinized. There are species of peridotite that are observed in the area but these are difficult to differentiate at this stage. Exposures of these ultramafic rocks occur along the steep banks of the Marga River while smaller outcrops were observed in the vicinity of the mineral property. The relatively wide to gently-sloping plateau-like ridges are covered by thick nickeliferrous laterite. These areas are the subject of ore exraction. Low dipping clastic rocks dominate the western half of the mapped area and alluvium occupies part coast zones.

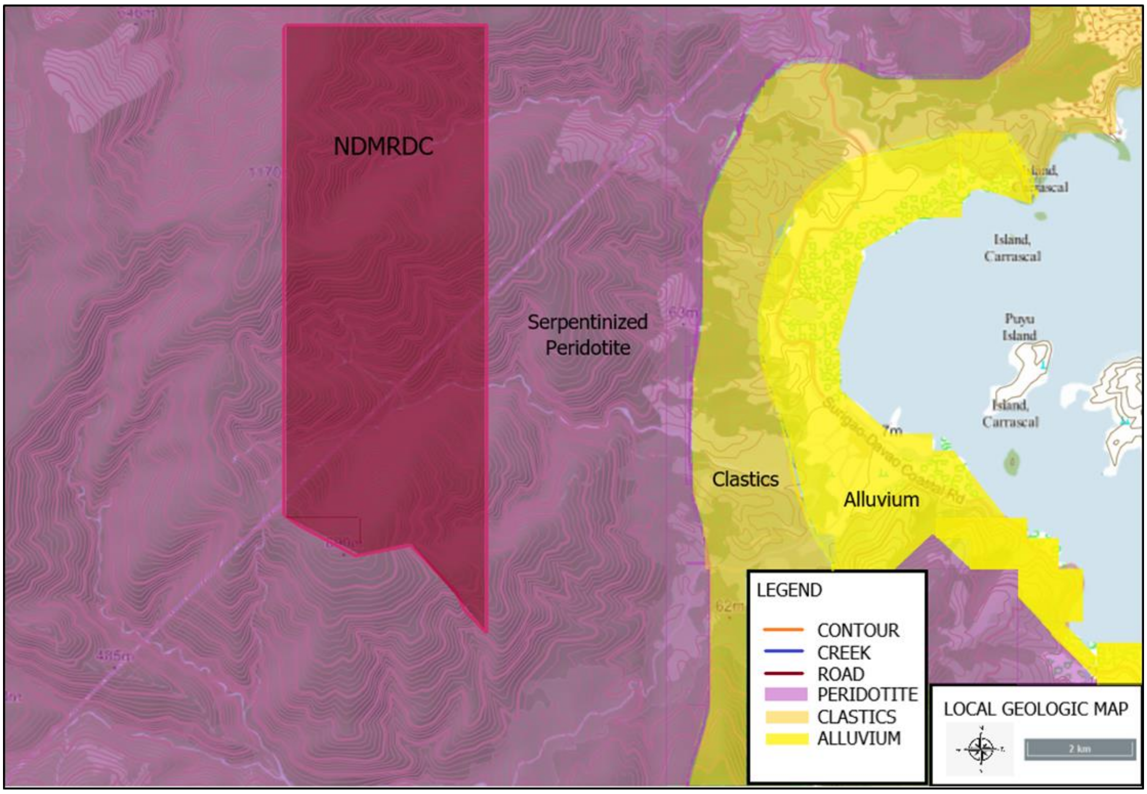

Figure 1.7.1: Geologic Map of the Project Site

1.7.1.1.1.2 Mineralization

The mining claim is mineralized with nickel, cobalt and iron as determined by previous studies and by the geologists of 4DVDI.

These minerals concentrate in considerable amount that may permit economic development. The process of concentration is called laterization which is the conversion of a rock into soil by chemical weathering and the subsequent leaching out of nickel into the deeper section of the laterite profile.

Ultramafics are the parent materials from where nickel laterites are normally produced. Under a tropical climate, at least three (3) layers of laterite are formed namely ferricrete, limonite, and saprolite.

Ferricrete is the uppermost layer that is almost devoid of nickel after it has been leached down. This layer is rich in iron and is equivalent to the red limonite in the laterite profile in **Figure 1.7.2**. Color is deep red or reddish brown. This is normally considered as overburden if one is interested in mining the nickel but because of the soaring prices of iron today, this has now become an ore, that is, if the concentration of iron is equal or greater than 50%.

Limonite is the transitory layer in the leaching out of nickel from the top layer into the lowest layer of the laterite profile. The color varies from light brown to yellowish brown. This is nickel-laden and usually mineable. This zone normally carries high nickel values that are of commercial significance and similarly of moderate iron content, i.e., 40-50% Fe. The typical grade varies from 0.8 to 1.5% Ni and increases at depth within the zone. In **Figure 1.7.2**, this is the yellow limonite and the transition zone in the profile.

Saprolite which is the lowest layer is where the leached nickel concentrates. This is the richest nickel depository and always desired in nickel mining. The concentration of nickel is high in this layer because there are two sources for enrichment, one is the leached-out nickel from the ferricrete and limonite layers and the inherent nickel content of the altered rock itself. Thus, this is sometimes called the zone of enrichment. Nickel values may generally range from 1.8 to 3 %. Iron is low at this layer.

SCHEMATIC LATERITE PROFILE

COMMON NAME	APPROXIMATE ANALYSIS (%) Ni	Co	Fe	MgO
RED LIMONITE	<0.8	<0.1	>50	<0.5
YELLOW LIMONITE	0.8 to 1.5	0.1 to 0.2	40 to 50	0.5 to 5
TRANSITION	1.5 to 2	0.02 to 0.1	25 to 40	5 to 15
SAPROLITE/ GARNIERITE/ SERPENTINE	1.8 to 3		10 to 25	15 to 35
FRESH ROCK	0.3	0.01	5	35 to 45

Source: Direct Nickel website

Figure 1.7.2: Approximate Analyses of the Different Layers in a Laterite Profile

The area covered by the drilling exploration is approximately 437 ha covering Areas 2 and 4 and located at the middle and northern sections of the mineral property. A total of 403 drill holes were completed. The location of the auger drillholes are shown in **Figure 1.7.3.**

As a result of the drilling program, a 3-dimensional solid model of the ore deposits was generated. This is illustrated in (a). In the model, the limonite forms part of the upper layer of the laterite and the saprolite lies directly beneath the limonite and sits above the fresh ultramafic bedrock.

Figure 1.7.3 illustrates the ore body on a topographic map and over a terrain map for better visualization. It is surrounded by steep slopes radiating from the ridge the laterite deposit caps. The general configuration of the ore body follows what appears to be a topographic plateau. The ore body measures between 100m and 850m in breadth and 2,600m in length following a generally north-south orientation. The thickness of the ore body is defined by the depth of the mineralized zones that terminates in the barren bedrock. The limit of the ore body bottom is determined by sudden decrease in content in Ni and Fe assays, as well as the physical fresh appearance of the bedrock.

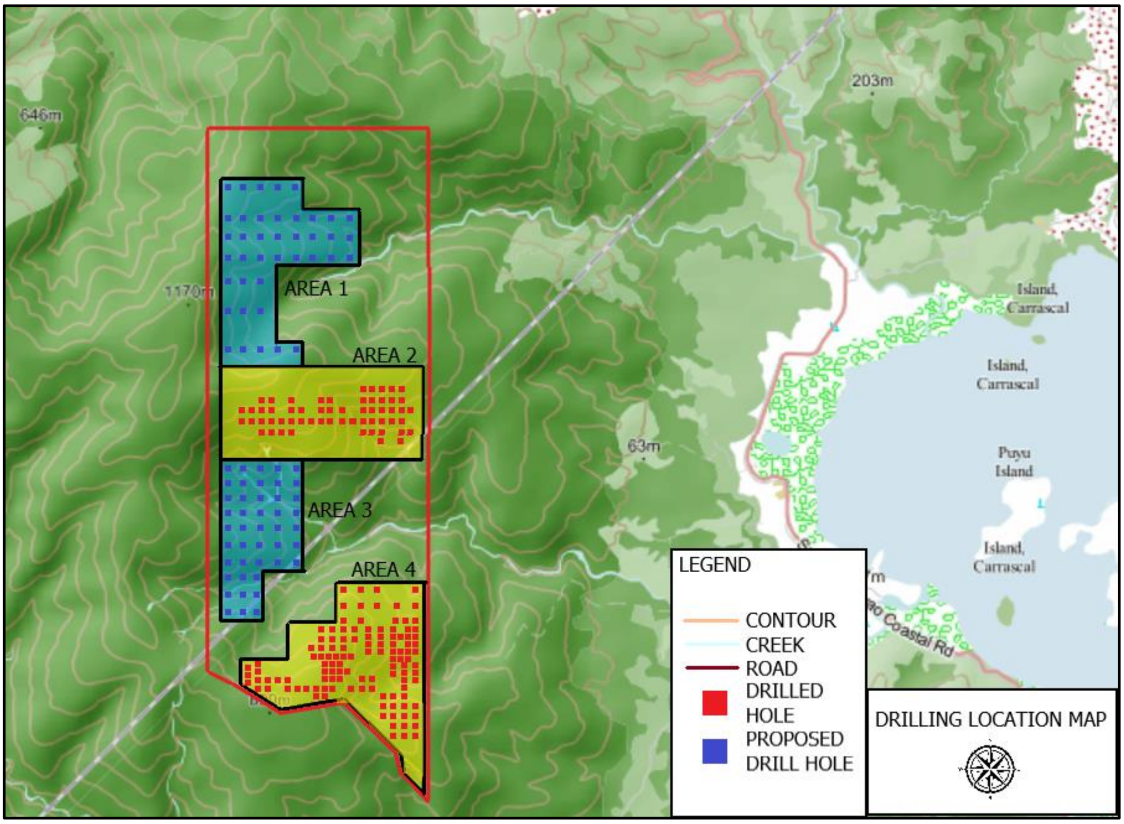

Figure 1.7.3: Location of Drill Hole Clusters

1.7.1.1.1.3 Tonnages and Grades (Reserves)

Based on the preceding presentation of the mineralization in the mining property, **Tables 1.7.2** and **1.7.3** summarizes the content of nickel and iron in the limonite and the saprolite layers of the laterite deposit. The limonite ore is estimated at 9,553,354 tons with an average nickel grade of 0.97% and an average iron grade of 46.41%. The saprolite meanwhile has an estimated tonnage of 1,946,916 with an average nickel grade of 1.50% and iron grade of 16.94%. Total ore reserve therefore amounts to 11,500,270 tons.

Table 1.7.2: Tonnage vs. Grades Based on Ni Range of Values in Limonite

Resource Class	Ore Class	WMT	%H2O	DMT	%Ni	%Fe
Measured (50m x 50m) Area 2	L1	153,738	35	99,930	0.75	49.09
	L2	90,558	35	58,863	0.77	46.85
	L3	726,408	35	472,165	1.19	42.46
Measured (50m x 50m) Area 4	L1	267,462	35	173,850	0.87	49.94
	L2	126,790	35	83,714	0.88	47.16
	L3	797,688	35	518,497	1.14	45.37
Indicated (100m x 100m)	L1	1,291,166	35	839,258	0.69	50.27
	L2	788,130	35	512,285	0.81	47.08

Resource Class	Ore Class	WMT	%H2O	DMT	%Ni	%Fe
Area 2	L3	1,555,388	35	1,661,002	1.17	41.57
Indicated (100m x 100m) Area 4	L1	1,378,620	35	896,103	0.78	50.27
	L2	508,680	35	330,642	0.84	47.12
	L3	1,866,726	35	1,213,372	1.13	45.61
Combined Measured and Indicated Limonite		**9,553,354**	**35**	**6,859681**	**0.97**	**46.41**

Table 1.7.3: Tonnage vs. Grades Based on Ni Range of Values in Saprolite

Resource Class	Ore Class	WMT	%H_2O	DMT	%Ni	%Fe
Indicated (50m x 50m) Area 2	S1	420,552	35	273,359	1.20	17.19
	S2	95,094	35	61,811	1.62	30.07
	S3	21,384	35	13,900	2.06	32.85
Indicated (50m x 50m) Area 2	S1	552,582	35	359,178	1.36	12.34
	S2	811,458	35	527,448	1.68	17.95
	S3	45,846	35	29,800	2.14	17.48
Total Indicated Saprolite		**1,946,916**	**35**	**1,265,496**	**1.50**	**16.94**
Combined Measured and Indicated Limonite and Saprolite		**11,500,270**	**35**	**8,125,177**	**1.06**	**41.42**

Table 1.7.4: Ore classification

Geologic_ Zone	**Abbreviation**	**Cut-off Grade***	
		%Ni	%Fe
Overburden	O	<1	>15
High Grade Iron Limonite	L1	<1	>=48
Medium Grade Iron Limonite	L2	<1	>=46<48
Low Grade Iron Limonite	L3	>=1<1.5	>=25
Low Grade Saprolite	S1	>=1<1.5	<25
Medium Grade Saprolite	S2	>=1.5<2	
High Grade Saprolite	S3	>=2	
Bedrock	BR	<1	<=15
*Prepared by NDMRC Engineering and Mine Planning			

1.7.1.1.2 Mining Rights Acquisition

The mining right over the area was acquired by NDMRC through MPSA 322-2010-XIII SMR issued on July 27, 2007, covering 1,352.38571 ha located largely in Carrascal, Surigao del Sur. For the future operations of the mining area, a DOA has been issued to 4DVDI on September 21, 2020. It is now undergoing approval from the MGB.

1.7.1.1.3 National and Local Permits or Clearances

Acquisition of ECC is ongoing as attested by this document while local permits are also being applied for including endorsement from LGUs. MOA with IP had already been obtained.

1.7.1.1.4 Bidding of Civil Works

This activity will precede the development works and will cover the construction of campsite, stockyard, hauling roads, clearing of the initial area for extraction and construction of environmental protection structures.

1.7.1.1.5 Preparation of Engineering Design and Drawings

Before the start of development, the final design for environmental protection structures shall already be prepared and implemented as part of the development phases.

1.7.1.2 Development/Construction Phase

The development phase generally involves the preparatory works that will facilitate the start of the operation. This will be done on the year preceding the actual operation and involves simultaneous of all components. Activities during the development phase could be grouped into the following:

- Establishment of the Campsite
- Preparation of the Adlay Causeway
- Preparation of the 70-hectare Stockyard
- Construction of the Hauling Roads
- Clearing of Extraction Areas
- Installation of Utilities
- Construction of Environmental Protection Structures

1.7.1.2.1 Establishment of the Campsite

The campsite will be established northwest of Adlay proper covering an area 10-15 ha. It will house several vertical and horizontal structures that include the administrative office, staff houses, guesthouse, mess hall, laboratory, indoor sports facility, fuel storage facility, warehouse, motor pool, parking areas, outdoor sports facilities, a promenade park, nursery and others. This is the central headquarters of the mining operations.

1.7.1.2.2 Improvement of the CTP Causeway

The existing causeway is located several kilometers from the highway and has an access width of 24 m and extending to 36 m when drainage is included. The roadway will be filled with gravel and soil and protected by rock armour.

1.7.1.2.3 Preparation of the Stockyard

The stockyard will be sited near the causeway and allotted adequate area to contain large amount of ore that will be segregated according to grade or generic classification. This place shall be cleared and matted with compacted laterite materials to avoid contamination from the underlying non-lateritic substrate or sedimentary rocks. It will also be fenced off to fend off wayward animals and even curious people. The yard shall be adequately drained to prevent entry of overland flow during rain events.

1.7.1.2.4 Construction of the Hauling Roads

Hauling roads had to be built from the national road to the mine site and in opposite direction, to the causeway. A small quarry at the mine site shall be established to supply the filling demand of the road and causeway. A typical roadway design had already been done and awaits implementation.

1.7.1.2.5 Clearing of Extraction Areas

The initial working area will be on Areas 2 and 4 of the laterite-laden ridge at the central and the southern boundary of the mining property, respectively. These areas will be cleared and subsequently mined by benching. Opening of the area will involve clearing of vegetation, stripping and stockpiling of overburden or the organic top soil for future backfilling of mined-out areas.

1.7.1.2.6 Installation of Utilities

Utilities will also be included like water system, power supply, drainage systems, etc. 4DVDIwill develop its own water system possibly tapping one of the tributaries of Ka-ayongan River or Nasipit River or available springs. On electricity, it will avail the power utility provided by SURSECO II in the area. On communications, the company will establish a radio network system, avail of cable and internet service provided by private companies, and enhance mobile communications.

1.7.1.2.7 Construction of Environmental Protection Structures

Environmental structures shall be constructed ahead of the mining operations. These structures include road ditches and silt traps or collector sump, contour holding or settling ponds, perimeter canal, sabo dams, and siltation ponds. The appropriate number and dimension shall be put on a blueprint. The siltation ponds shall be constructed across tributaries of Marga River. A provision for flocculation ponds must be included in the design. Perimeter canal if implemented will be divert runoff from Marga River to the small tributaries of Adlay River. This must be short and narrow and constructed only to specifically drain the active area. Contour settling or holding ponds are short and shallow pits that will initially settle large sediments before the stormflow goes into the sabo dams. A series of sabo dams should be built across gullies to break dynamic flood flows and further settle the sediments before the water is allowed to flow to the siltation ponds.

1.7.1.2.8 Development Equipment

Equipment to be used are dump trucks, backhoes, payloaders, dozers, graders, crushers, generators, service vehicles and other smaller ones. Most of these will be using diesel fuel.

1.7.1.2.9 Development Materials

Construction materials are cement, aggregates, base course, sand and gravel, soil, wood, steel, electrical materials, plumbing materials, sanitary materials and many more.

1.7.1.3 Operational Phase

Listed in **Figure 1.7.4** are the major activities involved in the operational phase of the proposed project.

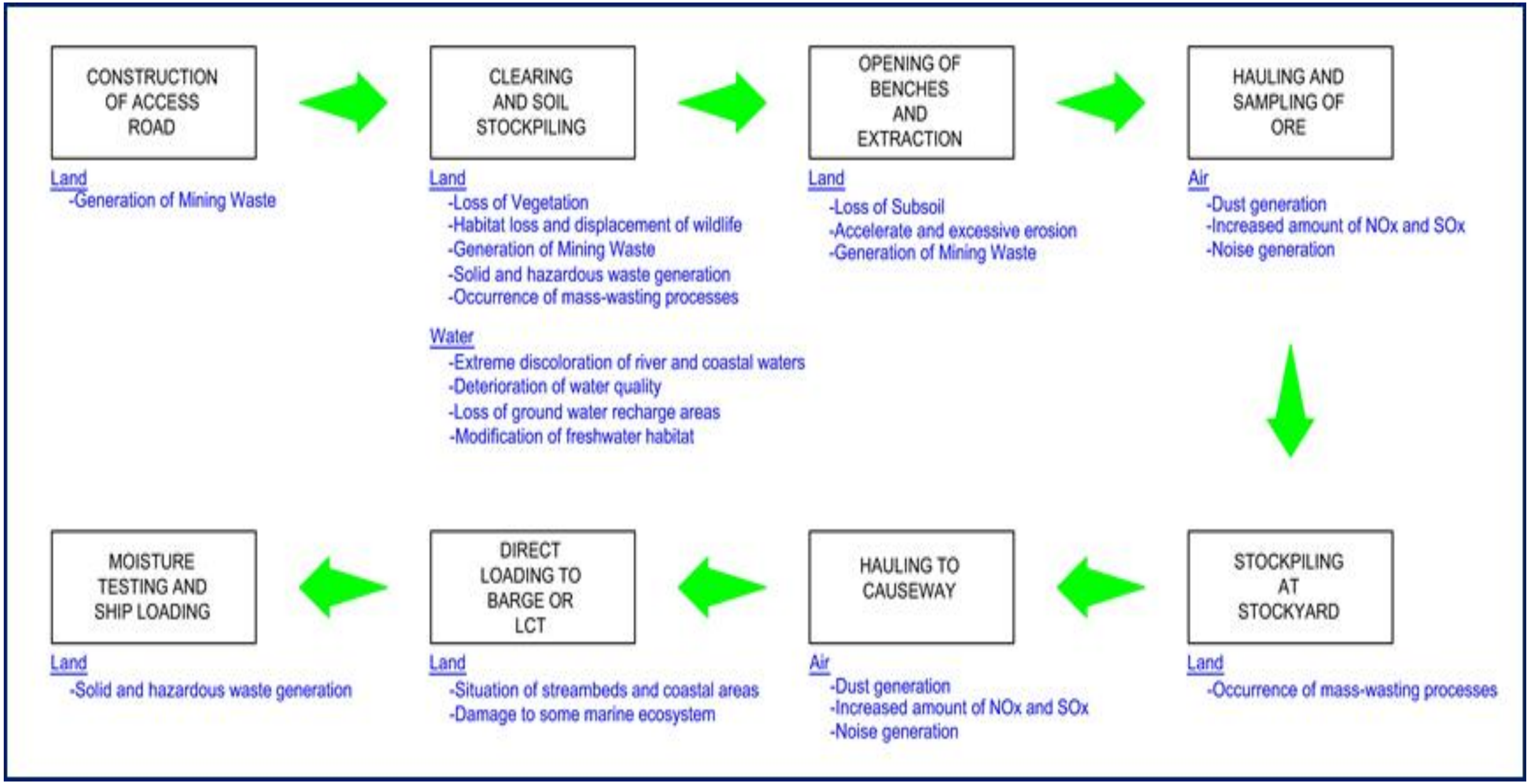

Figure 1.7.4: Activity Flow during Operation Stage

1.7.1.3.1 Major Components of Ore Extraction

Mining of laterite ore has two (2) components, limonite mining and saprolite mining.

Limonite Mining

After the construction of environmental control structures and access roads leading to the mine pit, clearing and grubbing will commence. Cleared and pushed waste materials consisting of overburden and remnants of plants and trees will be hauled to waste dump for future rehabilitation works. Cleared land will be surveyed to obtain the original topography of the mining area. The purpose of this topographic survey is to have a baseline data for the calculation of excavated volume during resource update and for production reconciliation.

Cut elevation will be established by locating areas of same elevation and staking to identify its actual position. Cut elevation will follow a 3m interval to follow the block size and production level plans. As soon as cut elevations are established, bench forming will commence.

Ore quality control will take over prior to actual ore extraction. Under OQC's standard operating procedure, all benches must be sampled through face sampling. Face sampling will be done on a regular 5m lateral interval over 3m bench height by creating 10 centemeters (cm) wide and 10cm deep channels from crest to toe of the bench. Sampling on vertical channels will be divided into 3m, each placed on separate sample bags and will be delivered to Assay for analysis. Upon release of assay results, channels will be ribboned based on production ore classification color coding scheme. This will be the basis of extraction and stockpiling plan. "No Ribbon - No Mining" policy will be strictly implemented to ensure the desired quality of mined ore. **Figure 1.7.5** shows how face sampling is done.

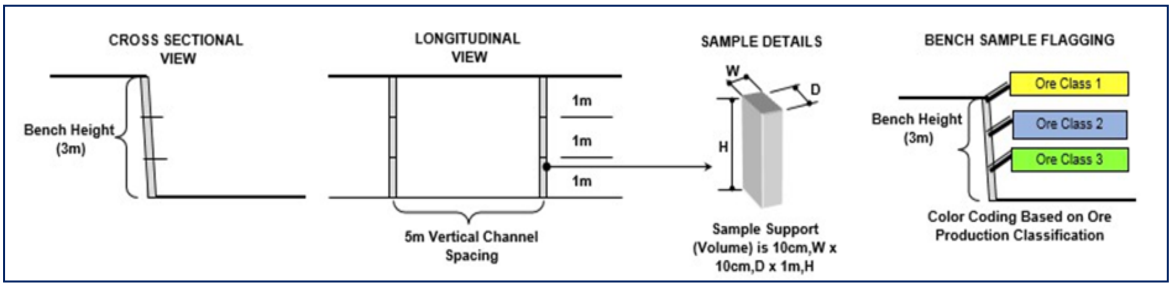

Figure 1.7.5: Face Sampling Protocol

Extraction and stockpiling plan will be based on ribbons placed by OQC. For different ore classification, there is an allotted space on stockyard. This is to avoid dilution and to have options for blending during shipments.

Fleet size will be dictated by the distance between mine pits to destination stockyard. Mining sequence will follow Load-Haul-Dump scheme. Loading at mine pit and receiving at stockyard will be facilitated by excavators with 1.2 m^3 capacity (i.e. EC 290) for shorter loading and receiving time. Hauling will be done by 14 m^3 (i.e. 10PD, Isuzu, Fuso) or 18 m3 (i.e. Chenglong, Howo) dump trucks.

During mining, quality assurance protocol will be implemented through truck sampling. All trucks will pass and stop on sampling stations positioned along main haul roads. Samples will be taken on one point using scoop (JIS 100) and samples will be placed on sample bags. For every 30 dump trucks, there is a composite sample representing the tonnage equivalent to 30 dump trucks. Assay result will dictate the Ni and Fe grade of stockpile inventories. **Figure 1.7.6** shows the procedure of truck sampling.

For paper inventory purposes, 14 m^3 and 18 m^3 dump trucks will use 15 and 20 WMT/trip truck factor.

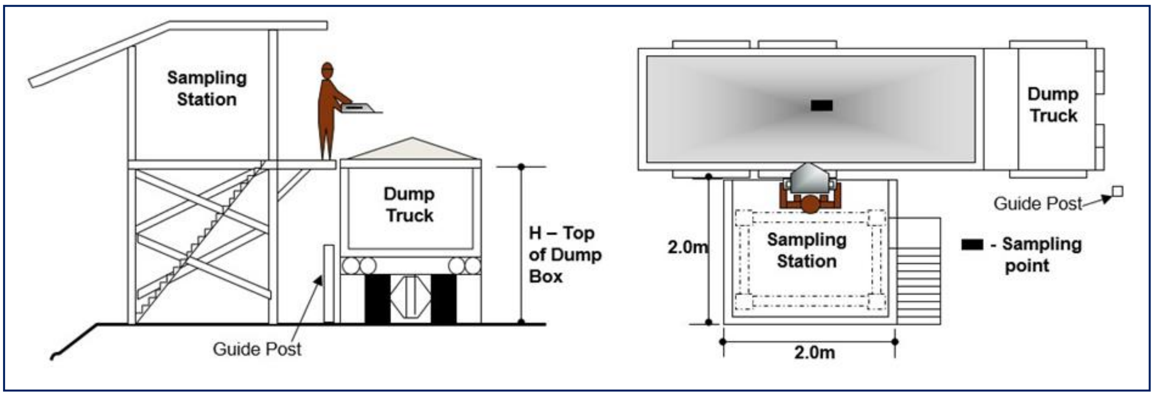

Figure 1.7.6: Truck Sampling Protocol

Stockpiles will be covered with canvass sheets for moisture quality control as well as to avoid erosion during rains. Canvass sheets will be removed during good weathers to allow natural sun-drying. As a monitoring protocol, stockpiles will undergo volumetric survey. This is to provide a technical way of monitoring the quantity of ore moved and stockpiled.

Saprolite Mining

Saprolite zone will be encountered after overlying limonite zone is completely excavated. Same with limonite mining, bench sampling will be done prior to mining. Same protocol will be implemented; the only difference is that saprolite face sampling will be done at a narrower interval of 1 m.

Saprolite mining will follow Prepile - Beneficiation - Ore Trans procedure. Saprolite prepiling covers in-pit segregation of boulders, piling, loading to dump trucks, hauling, and receiving at prepile yards. Saprolite piling at prepile yards will be done every 10 dump trucks. During hauling, all dump trucks will pass sampling stations for sample collection and 5-point sampling will be implemented using pick and scoop. For every 10 dump trucks, there is a composite sample representing one (1) pile in the prepile yard. All piles will be covered with canvass sheet while waiting for its assay result.

Piles falling under the same ore classification will be combined into one stockpile to conserve space in the prepile yard. During the process of combining piles, a dedicated excavator will do second stage segregation and size reduction. Resulting pile will follow windrow piling scheme for convenient covering and uncovering of canvass sheets. During favorable weather, windrow piles will be turned to expose other parts of the pile to direct sunlight for sundrying. Moisture content of each pile is monitored at a regular interval by collecting samples and sending to laboratory for moisture content determination. This is the saprolite beneficiation process.

Once a windrow pile in prepile yards meets the desired moisture quality, these piles undergo ore transfer by transferring to final stockyards. Piling at final stockyards will be done every 30 dump trucks. During hauling, all trucks are sampled in sampling stations through 5-point sampling using scoop and pick. For every 30 dump trucks, there is a composite sample representing one (1) pile in the final stockyard. All piles in the final stockyard is provided with canvass sheet for cover.

The final stage in saprolite mining is grade banding. Assay result of hauled saprolite ore during ore transfer will be the basis of grade banding as well as its final Ni and Fe grade. Piles falling under the same grade band will be combined to save space in the final stockyard. All piles will be covered with canvass sheet that will be removed during good weather to further dry the saprolite ore. Saprolite ore in the final stockyard is classified as shipping quality ore in terms of moisture, grade, and homogeneity.

Figure 1.7.7 shows the flow of mining and barging process.

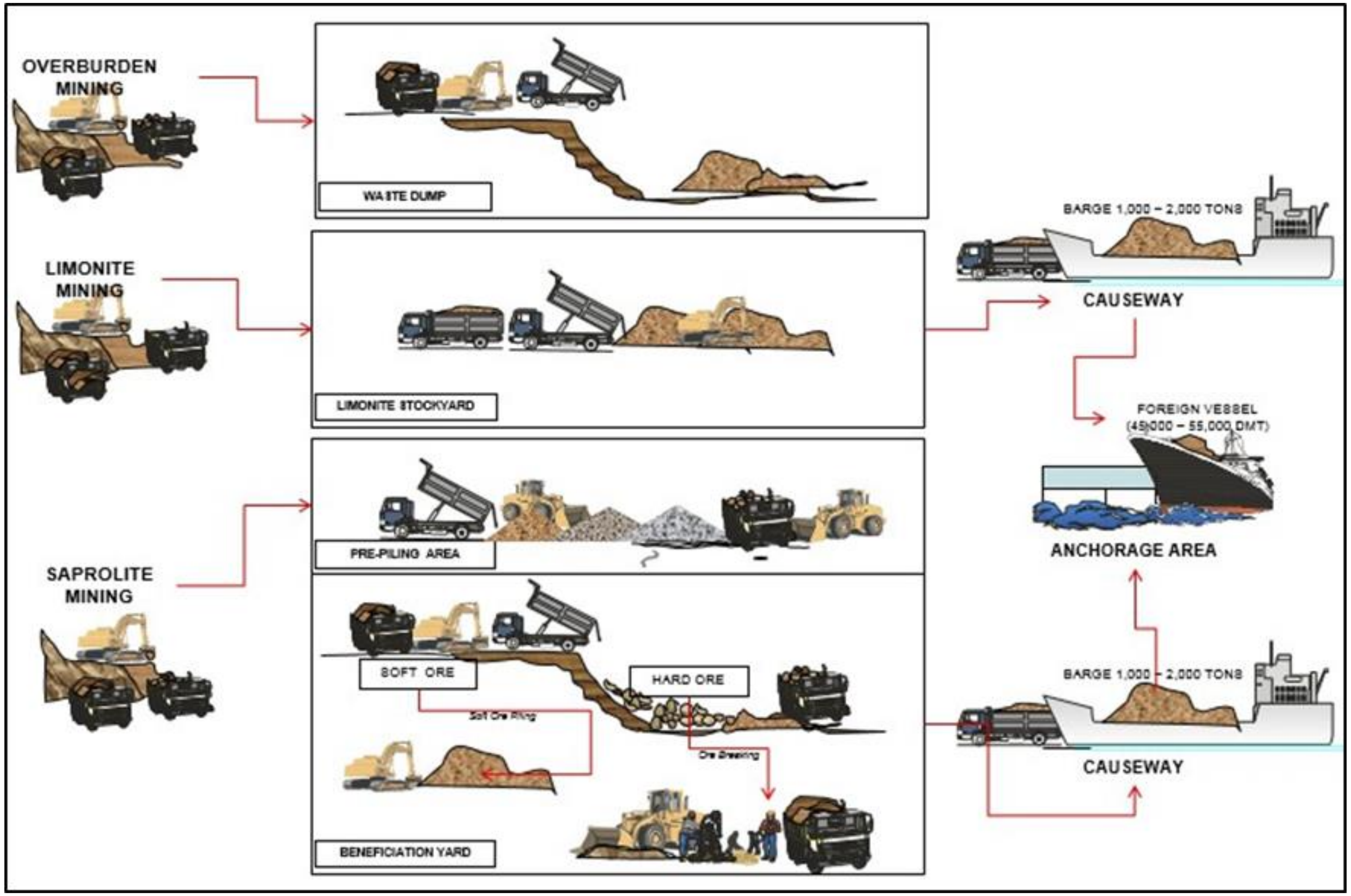

Figure 1.7.7: Mining and Barging Process Flow

1.7.1.3.2 Benching and Rehabilitation

As cited above, the general process of ore extraction starts from stripping of overburden, extraction through benching, stockpiling with the extraction site and loading to hauling trucks (**Figure 1.7.8**). After mining out an area, this is properly shaped up retaining the benches used in the extraction process. The benches are then covered with the organic top soil or mine waste saved earlier in a waste dump. To prevent rain splashing on the returned soil, this is covered with leaves twigs, litters, and other plant remains. At the toes of batters, small ditches had to be dug to control runoff and prevent scouring. Planting of seedling will start at the advent of the rainy season and should end two (2) months before the rainy season ends.

The purpose of the drainage ditch (**Figure 1.7.9**) is to collect water from the berm and train it to a dedicated canal. This will prevent rilling and gullying in the batter or bench slope which typically collapses when oversaturated. It is important to incorporate in the bench design such component since it is difficult to revegetate the batter if it is exposed to constant excessive erosion. The ditch will eventually help prevent excessive erosion in the berms and batters.

The trees that will be felled during clearing/stripping will be used for construction of camp facilities if still needed or donated to the LGUs for the construction or repair of government buildings particularly schools or turned over to the DENR for their disposal. Normally, the trimmings and leaves and even the other plant parts like twigs, branches and roots will be mixed with organic soil that will be used as substrate for new seedlings to be planted on the benched or re-shaped mined-out area.

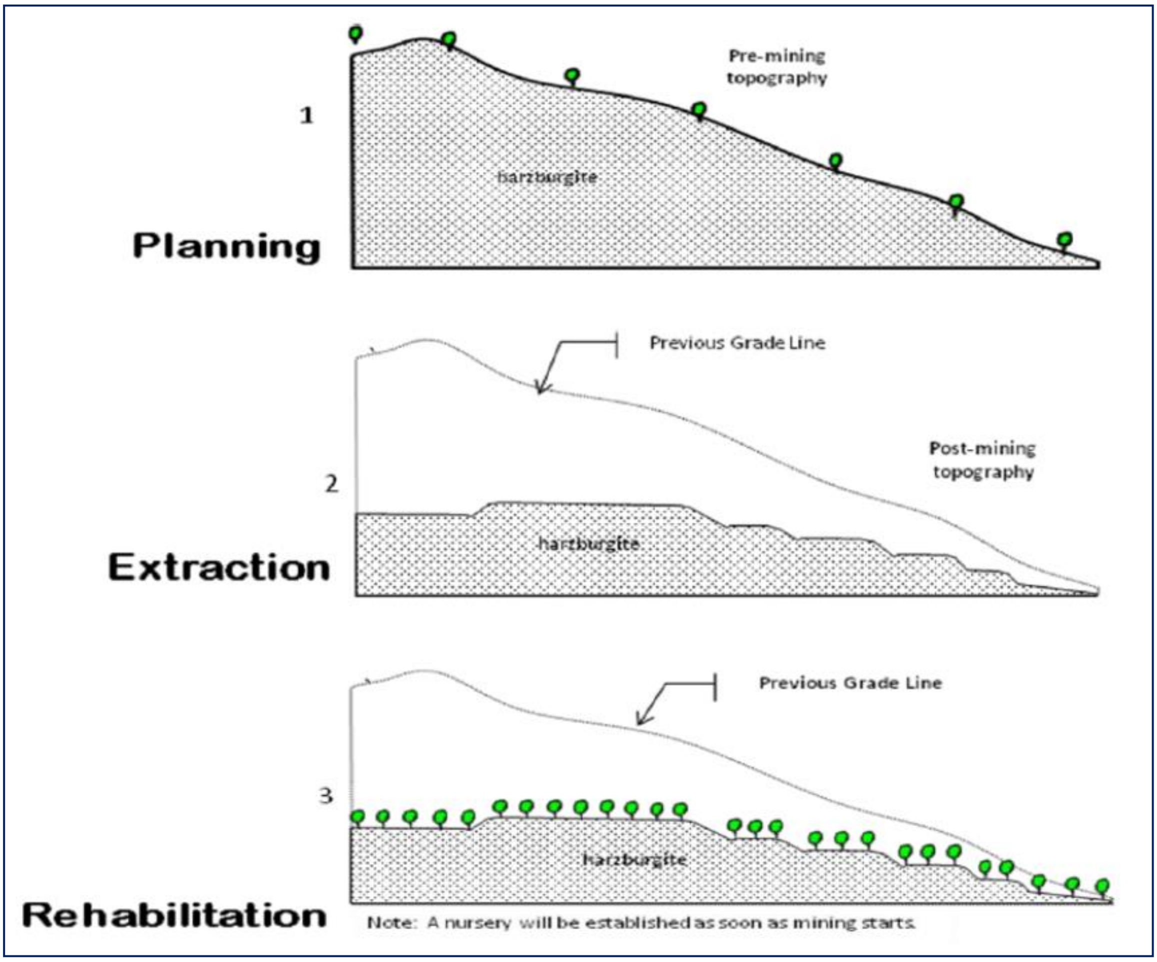

Figure 1.7.8: General Stages of Mining with Progressive Rehabilitation

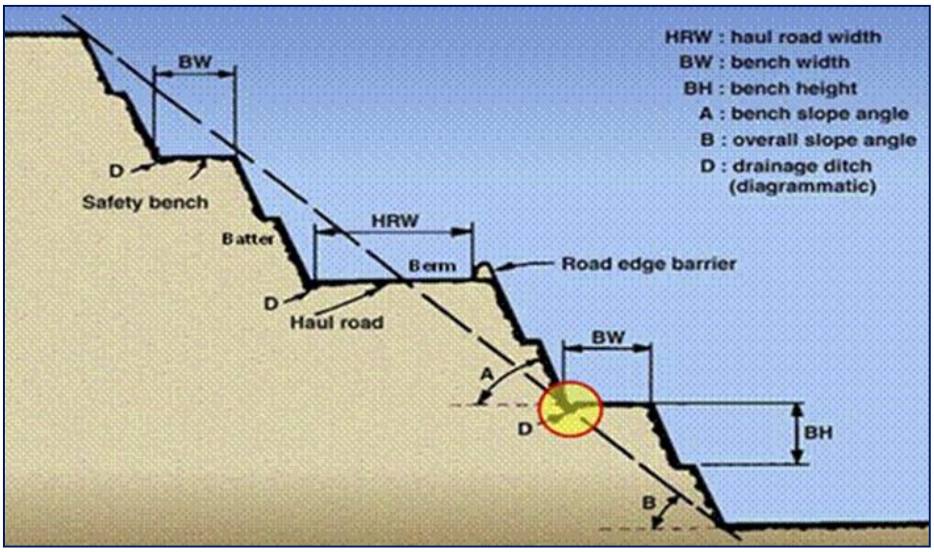

Figure 1.7.9: Components of a Complete Bench showing the Drainage Ditch

1.7.1.3.3 Annual Development and Rehabilitation Plan

Figures 1.7.10 and **1.7.11** present the Development and Rehabilitation for the entire life of the mine.

The first step of the Development and Rehabilitation Plan involves the clearing of the pre-determined extraction area. This is mined based on the desired output as contained in the 7-year development plan. Based on the existing geological information particularly the bottom of the laterite deposit, the area is determined beforehand and thus, the operation will be confined only within it. In this case, the impact will be limited in specific areas and not the general areas where the environmental measures may not cope-up with ore extraction. This may be referred to as progressive mining and because of this approach, implementation of mitigating measures will also be progressive and intensive and not widespread where control is difficult

Open cut method will be used to extract the ore and this requires the removal of the laterite deposit on the top of ridge or plateau where economic deposits are formed. This is pursued by benching from the top of the deposit and going down to the bottom. Since saprolite will be mined, it is expected that what will remain in the benches after mining are rock surfaces and without any soil layer. During the last stages of mining in any particular extraction area, the surface should have already been benched before the contractor leaves so that no extra work will be needed to re-shape it into a terraced surface.

During the development, it also suggested that protection of Marga River be incorporated in the mining plan itself wherein the approach would be to allow runoff to flow towards Adlay River only. This means that runoff from extraction areas will be caught by perimeter canal and drains this to a huge settling or siltation pond prior to releasing to Adlay River. This will totally avoid the installation of mitigating measures in Marga River and reduce the cost of environmental protection.

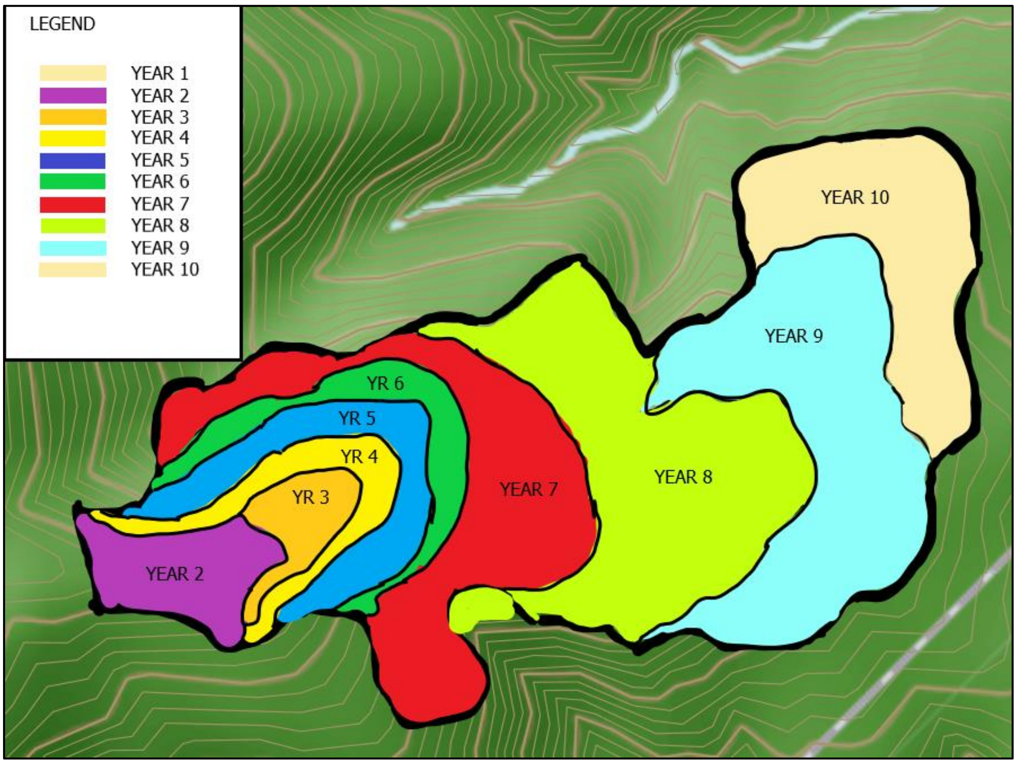

Figure 1.7.10: Annual Development Plan in Area 2

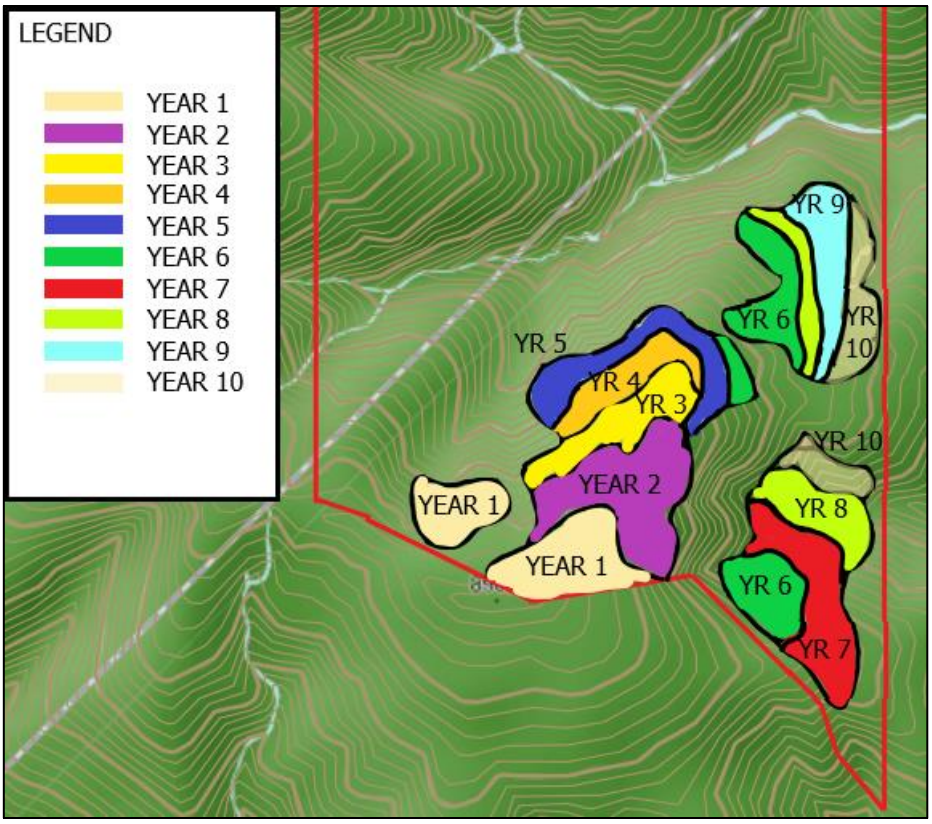

Figure 1.7.11: Annual Development Plan in Area 4

1.7.1.3.4 Ship loading Activity

Beneficiated ores in pier yards are loaded into dump trucks and hauled and unloaded to the barges or LCT's (Light Carrier Transport) of 800 to 2,500-ton capacity. Sampling at every truckload is done to determine the final assay of the shipment. Loading into the LCT is done with the use of wheel loader. The ore is then conveyed to the foreign vessel anchored farther away from the beaching area. It is subsequently scooped using the vessel's clamshells attached on the crane and transferred into the different hatches of the ship and so on until the barge is emptied of its load. Daily draft survey is conducted to determine the tonnage loaded and the balance of the ship as well. Monitoring of the quality and quantity of ore is done from time to time to conform to the buyer's specification. Time delays during loading operation are usually due to the bad weather, rough seawater condition and equipment breakdowns on the foreign vessel or on barges. The normal loading operation usually takes 5 to 6 days to load a 55,000 wmt of ore considering good weather and seawater condition and also loading equipment breakdowns. This is usually a 24-hour operation

4DVDI will install a conveyor system in the causeway to eliminate the use of LCTs. The conveyor system will operate at a rate of 1,000 dmt/hr of ore and therefore can finish loading a 55,000-tonner bulk carrier in just 3 days. The conveyor shall start from the pier stockyard to the causeway.

The operation needs at least 2,000 workers distributed in the different departments like mining (including laborers in the breaking or fragmentation of hard ore), engineering, admin and finance, and support units. This will be sourced from the qualified human resource of the community.

1.7.1.4 Abandonment

The mine site will be abandoned five (5) after the laterite deposit had been exhausted, possibly, after 16 years assuming the life of mine is eleven (11) years. Prior to abandoning the mining area, 4DVDI is required to implement the Final Mine Rehabilitation and Decommissioning Plan (FMRDP) to make sure that all rehabilitation measures are implemented including re-vegetation. The FMRDP shall be prepared by 4DVDI and submitted to MGB prior to the start of the operations.

During abandonment, all structures will be removed from the site unless requested by the residents in the area or by the local government unit, to be retained. All wastes and spoils from mining shall be disposed of in environmentally-safe manner as guided by the FMRDP. The newly planted trees shall be nurtured until they acclimatized and survive the young age. All unstable slopes shall be stabilized, and erodible soils amply protected.

1.7.2 Project Schedule

4DVDI intends to finish all development works within one (1) year after the ECC had been procured. The schedule of implementation is presented in **Table 1.7.4**.

Table 1.7.5: Monthly Development Schedule

Activity	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Causeway Preparation												
Hauling road Construction												
Campsite Construction												
Stockyard Preparation												
Clearing and Minesite Preparation												
Construction of Environmental Structures												

1.8 MANPOWER

The entire development phase needs more than a hundred workers for the entire development period. Workers that will be employed include management staff, technical personnel, equipment operators, carpenters, masons, finishing workers, unskilled laborers, plumbers, drillers and office workers. Some of the jobs will be contracted out. The hiring of laborers will be left to the contractors, but they are bound by an agreement that the labor force will mostly come from the community. The management is committed to hiring local workers for its mining operations or activities.

4DVDI will employ 495 (304 on Mine Claim Owner side and 191 on Mine Contactor side) employees at the peak of its operation. During the development year (Year 0), the project will initially employ 78 personnel, majority being local skilled and R/F. This number will gradually increase over the years peaking during the 5th and 6th year which is directly proportional to the annual mine and shipment target.

4DVDI will comply with the equal opportunity principle in hiring persons with disability (PWD) as well as women. A qualified employee, whether a woman or with disability is subject to the same terms and conditions of employment and the same compensation, privileges, benefits, incentives and allowances with other qualified employee.

For plantilla-based/regular employees, monthly salaries or wages for services rendered by an employee are timely paid twice a month via bank transfer. For transparency, the said payments are duly acknowledged by the employees through electronic and/or manual pay slips. Thirteenth month pay is likewise paid to all qualified employees in compliance with the relevant laws, rules and regulations. Qualified employees also enjoy various benefits such as vacation leaves, sick leaves, overtime pay, health insurance, health plan, separation pay, retirement plan and allowances, as well as safety provisions like Personal Protective Equipment (PPE) and personal emergency kits, contributions and remittances for SSS, Philhealth and PAG-IBIG fund and other welfare benefits. Employees who have queries on the salaries or benefits they receive or are entitled to may bring their concerns with the Human Resources Department.

For contractors or manpower agencies who engage contractuals, 4DVDI will undertake an accreditation process wherein contractors are required to submit documents to establish that they are duly registered with the SEC or Department of Trade and Industry and with the Bureau of Internal Revenue and that they have substantial capital and/or investments to ensure that they can perform the work to be done and are compliant with relevant laws and regulations, specifically on the prohibition against labor-only contracting. Without this accreditation, 4DVDI will not engage the services of the contractor and ensure compliance by the contractors with all the rights and benefits under labor laws, rules and regulations. 4DVDI will strictly enforce such contractual provisions in order to ensure that the contractor's employees are paid all statutory benefits and that the contractor comply with all the requirements as provided by law.

Provided in **Table 1.8.1** are the tabulation of manpower requirements which do not discriminate against sex and age as long as the worker is qualified and fit to work. For all of these manpower requirements, applicants from the host community are given priority subject to the qualifications of the applicant to the position. Job vacancies/openings are posted in the bulletin boards of the host barangays and municipalities for qualified locals to have an opportunity to work for 4DVDI. Local officials sometimes provide recommendations for qualified workers

Table 1.8.1: 10-Year Manpower Requirement per Department of 4DVDI

Department/ Position	Year									
	1	2	3	4	5	6	7	8	9	10
Executive Management										
President	1	1	1	1	1	1	1	1	1	1
Executive Secretary	1	1	1	1	1	1	1	1	1	1
Vice President	1	1	1	1	1	1	1	1	1	1
Comptroller	1	1	1	1	1	1	1	1	1	1
Accountant	1	1	1	1	1	1	1	1	1	1
Office Administration Officer	1	1	1	1	1	1	1	1	1	1
Subtotal	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
Office of the Resident Mine Manager										
Resident Manager	1	1	1	1	1	1	1	1	1	1

Department/ Position	Year									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Secretary	1	1	1	1	1	1	1	1	1	1
Driver	1	1	1	1	1	1	1	1	1	1
MEPEO Officer	1	1	1	1	1	1	1	1	1	1
Nursery Supervisor	1	1	1	1	1	1	1	1	1	1
Subtotal	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**
Environmental Department										
Research/Reforestation Officer	1	1	1	1	1	1	1	1	1	1
Community Coordinator/Clerk	1	1	1	1	1	1	1	1	1	1
Nursery Aide	4	4	4	4	4	4	4	4	4	4
Environmental Aide	4	4	4	4	4	4	4	4	4	4
CRD Officer	1	1	1	1	1	1	1	1	1	1
ICE-CD Coordinator	1	1	1	1	1	1	1	1	1	1
Subtotal	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**
Mining Department										
Mine Superintendent										
Mine Foreman										
Ore Sizing, Ore Sorting Foreman										
Planning Engineer										
Mine Capataz										
Grade Control Engineer										
Planning										
Total Manpower Requirement	**156**	**549**	**549**	**741**	**741**	**851**	**851**	**741**		

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1.9 INDICATIVE PROJECT INVESTMENT COST

Total project cost is estimated at P208,130.600.00,

2. ASSESSMENT OF ENVIRONMENT IMPACTS

2.1 LAND

2.1.1 Land Use and Classification

2.1.1.1 Existing Land Use

Based on the old 10-year Comprehensive Land Use Plan (CLUP) of Carrascal (2002-2012) which is still due for updating, land uses in the municipality were classified into 11 types of which the first three largest are Forest and Mineral Reserve, Agriculture, and Beach/Shoreline/Tourism (**Table 2.1.1**). **Figures 2.1.1** presents the existing land use maps of Carrascal, in which the Mineral Land Reservation were superimposed to determine its relative broadness against Forestland. **Figure 2.1.1** also shows the area covered by the reservation relative to the administrative jurisdiction of the municipality, which occupies more than half of the town's area.

Table 2.1.1: Area Distribution of Existing General Land Uses in Carrascal

Land Use	Area (ha)	Percentage (%)
Built-up area	150.00	0.40
Agriculture	3,053.00	8.06
Industrial (Urban)	4.00	0.01
Forest/Mineral Reserve	33,377.00	88.13
Open Grassland	305.00	0.80
Swamp/Marshes/Mangroves	220.00	0.58
Fishpond	12.00	0.03
Inland Water/Open Space	298.50	0.79
Beach/Shoreline/Tourism	400.50	1.06
Roads	52.00	0.14
TOTAL	**37, 872.00**	**100.00**

Source: CLUP of Carrascal (2002-2012), MPDO Carrascal

Forest and Mineral Reserve

The existing land use is predominantly the forest/mineral type of which 88% or 33,377ha is covered with forests and minerals out of the 37,872ha comprising the total area of the town. Forests typically grow in the mountains and Carrascal is largely made up of mountain ranges thus the presence of broad tracts of forestland. These are mostly distributed in Barangays Pantukan, Babuyan, and Panikian.

According to the CLUP, a considerable portion of the municipality's forest areas have been subjected to indiscriminate kaingin practices and illegal logging activities, specifically in Barangay Pantukan, Adlay, Babuyan and Panikian. Disruption of the ecological balance manifested by landslides, soil erosion and siltation of water ways have been observed in these areas. Now, mining has arrived, and no vegetation is left when laterite is extracted from the ground.

Agriculture

The agricultural areas in the municipality is largely distributed in the southern municipalities where vast tracts of flatlands exist. Highland farming is also adopted by barangays and sitios located closer to the mountains. The agricultural lands are spread over the large plains of Barangays Panikian, Tag-anito, Bacolod, Gamuton, Saca, and Bon-ot. This covers an aggregate total of 3,053ha or 8.06% of Carrascal's total land area. It is devoted to the cultivation of rice, corn, coconut, root crops, vegetables and others. On the other hand, Pantukan, Babuyan, Adlay and Panikian are concentrating on vegetables, root and other tuber crops which are normally products of cultivation the footslopes and midslopes of the mountain ranges. These commodities are also grown in almost all barangays.

Shoreline and Beaches dedicated to Tourism

The beaches lie in coastal barangays of Doyos, Bay-bay, Bon-ot and constitute the third largest use among the land uses. Although not in the league of the forest/mineral land use, it ranks third among the rest and encompasses 400.50 ha of the total area and distributed along coastlines of several barangays some of which are already mentioned above and a number of islets randomly occupying Carrascal Bay.

Other Uses

Other significant land use types are grassland, inland water bodies and open spaces, swamp/marshes/mangroves, and built up areas. These were previously cultivated areas but were later abandoned to its unproductive character. Grasslands are observed in the rolling topography of Adlay and occupies an area of 305 ha representing 0.8% of the total town area. Inland water bodies and open space includes rivers and creeks that are essentially perennial, and those areas left uncultivated or unused. The combined area of this land use type is 298.50 ha, a mere 0.79% of the town's total area. Swamps/marshes/mangroves have a collective area 220 ha located normally in estuaries and water-logged areas representing 0.58% of the town's total area. The built-up area is only 150ha and representing 0.40% of the total area of Carrascal. The largest built up area is located in the town proper where four barangay centers conglomerate.

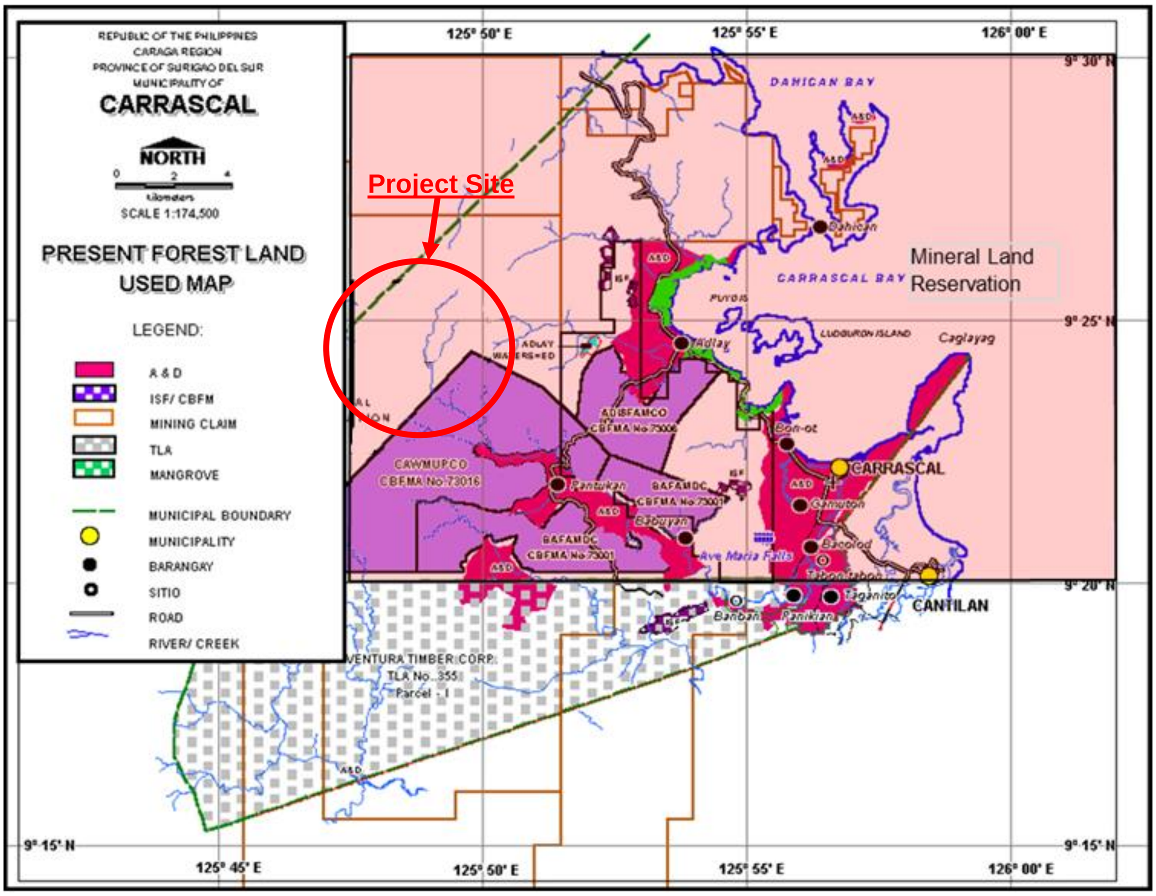


Figure 2.1.1: Existing Land Use Map of Carrascal

2.1.1.2 Environmental Critical Area

Environmentally Critical Areas (ECAs) are environmentally sensitive areas declared under Presidential Proclamation No. 2146 of 1981 where significant environmental impacts are expected if certain types/thresholds of the project are located, developed or implemented in it. **Table 2.1.2** presents the list of ECA and their relevance to the project site.

Table 2.1.2: List of ECA and Relevance to the Project Site

No.	ECA Category	Technical Description of ECA Category based on DAO 2003-30	Presence within the Project Site	Description, Distance (in aerial km)
1	Areas declared by law as national parks, watershed reserves, wildlife preserves, and sanctuaries	The laws referred to by this provision are Presidential Decree No. 705, as amended, otherwise called as the *Revised Forestry Code, Republic Act 7586* or the *NIPAS Act*, and other issuances including other proclamations, executive orders, local ordinances, and international commitments and declarations.	Not present within the project site.	Not applicable
2	Areas set aside as aesthetic, potential tourist spots	Aesthetic potential tourist spots declared and reserved by the DOT or other appropriate authorities for tourism development.	Not present within the project site.	Not applicable
3	Areas that constitute the habitat of any endangered or threatened species of indigenous Philippine wildlife (flora and fauna)	This refers to areas considered as wilderness areas and areas identified by the PAWB/BMB to be natural habitats of endangered or threatened, rare, and indeterminate species of flora and fauna, as defined by PAWB/BMB.		***Refer to Terrestrial Ecology Section***
4	Areas of unique historic, archaeological, geological, or scientific interests	This refers to areas that are more than 100 years old (now superseded by new law RA10066, reduced to 50 years old) and declared by the National Historical Institute, National Museum, or National Commission for Culture and the Arts, through national or local laws or ordinances as areas of cultural, historical, and scientific significance to the nation, (e.g., declared national historical landmarks, geological monuments, and paleontological and anthropological reservations).	Not present within the project site.	Not applicable
5	Areas that are traditionally occupied by cultural communities or tribes	This refers to all ancestral lands of the National Cultural Communities in Section 1 of P.D. No. 410 and settlements designed, implemented, and maintained by the PANAMIN for national minorities (non-Muslim hill tribes referred to in Presidential Decree No. 719) as may be amended by R.A. 8371 or the Indigenous Peoples Rights Act of 1997 and its Implementing Rules and Regulations.	Present within the project site.	**CADT NO. R13-CLA-0906-048** in Guigaquit, Tubod, and Claver, Surigao del Norte of the Mamanwa tribes determined by NCIP
6	Areas frequently visited and/or hard-hit by natural calamities (geologic hazards, floods, typhoons, volcanic activity, etc.)	The area shall be so characterized if any of the following conditions exist: - Geologic hazard areas: This refers to all areas identified by the Mines Geosciences Bureau (MGB) as geologic hazard areas. - Flood-prone areas: This refers to low-lying areas usually adjacent to large active water bodies experiencing inundation of at least 2m, twice a year for the last five years prior to the year of reckoning. - Areas frequently visited or hard-hit by typhoons: This refers to all areas where typhoon signal No.4 was hoisted for at least twice a year during the last five years prior to the year of reckoning. - Areas prone to volcanic activities/ earthquakes: This refers to all areas identified as such by the Philippine Institute of Volcanology and Seismology (PHIVOLCS) (e.g., areas within permanent exclusion zones of active volcanoes or areas within the required minimum buffer zone of fault zones as determined by PHIVOLCS).	Present in the project site.	Low susceptibility to flooding. *Refer to Hydrology Section.* Safe from volcanic hazards; low to moderate risk from earthquake and related hazards. ***Refer to Geology Section***

No.	ECA Category	Technical Description of ECA Category based on DAO 2003-30	Presence within the Project Site	Description, Distance (in aerial km)
7	Areas with critical slope	This refers to all lands with slopes of 50% or more classified as geohazard by MGB. Such slope conditions favor their natural susceptibility to geohazards such as landslides.	Present within the project site.	Slope category of the area falls under 18% up to >50 % (hilly to mountainous). ***Refer to Geology Section***
8	Areas classified as prime agricultural lands	Prime agricultural lands refer to lands that can be used for various or specific agricultural activities and can provide optimum sustainable yield with minimum inputs and development costs as determined by the Department of Agriculture.	Not present within the project site.	
9	Recharge areas of aquifers	Refers to sources of water replenishment where rainwater or seepage actually enters the aquifers. Areas under this classification shall be limited to all local or non-national watersheds and geothermal reservations.	Not present within the project site.	Not applicable
10	Water bodies characterized by one or any combination of the following: tapped for domestic purposes; within the controlled and/or protected areas declared by appropriate authorities; which support wildlife and fishery activities.	Water bodies shall refer to waters that are tapped for domestic purposes or those which support wildlife and fishery activities within declared protected areas, including the buffer zones.	Present within the project site.	The waterbodies within the MPSA site includes the **Marga River and Caayungan River,** both tapped for domestic purposes. ***Refer to Hydrology Section.***
11	Mangrove areas characterized by one or any combination of the following conditions: with primary pristine and dense young growth; adjoining mouth of major river systems; near or adjacent to traditional productive fry or fishing grounds; areas which act as natural buffers against shore erosion, strong winds and storm floods; areas on which people are dependent for their livelihood.	Mangrove areas shall be characterized by one or any combination of the following conditions: - With primary pristine and dense young growth - Adjoining mouth of major river systems; - Near or adjacent to traditional productive fry or fishing grounds; - Areas that act as natural buffers against shore erosion, strong winds and storm floods; and - Areas on which people are dependent for their livelihood, pursuant to and taking into consideration *Republic Act 7161*, which prohibits the cutting of mangrove species.	Not present within the project site.	Not applicable
12	Coral reefs characterized by one or any combination of the following conditions: - With 50% and above live coralline cover; - Spawning and nursery grounds for fish; - Act as natural breakwater of coastlines	Characterized by one or any combination of the following conditions: - With 50% and above live coralline cover; spawning nursery grounds for fish; and act as natural breakwater of coastlines.	Not present within the project site.	Not applicable

Source: Presidential Proclamation No. 2146 (1981)

2.1.1.3 Impact in Terms of Compatibility with Existing Land Use

Therefore, there is no issue in terms of compatibility with the existing land use. The 1,352.38571 ha project site is situated within the Mineral Land Reservation declared through Presidential Proclamation No, 391 series of 1939 during the term of President Manuel L. Quezon.

2.1.1.4 Impact on Compatibility with Classification as an ECA

The project site may be potentially affected by ground shaking and landslide in the event of an earthquake; likewise, flooding may affect areas that are closer to the Caayungan and Marga rivers. These projections along with other geological hazards will be considered during the detailed mine planning and design stage.

Also, the MPSA site covers the section of Caayungan and Marga rivers, which is tapped for domestic purposes and supports terrestrial wildlife. The proposed project, however, will not be drawing water from this river for its operations. Likewise, measures such as rendering buffer zones and concentrating mining activities away from this inland water bodies, including putting up drainages during torrential and heavy rains will be implemented to avoid disturbance of the nearby rivers.

4DVDI is committed to address the impacts of the natural and geologic hazards. Typhoon impacts may be mitigated through regular coordination with PAGASA and adjustment of construction schedules in relation to bulletins issued by the said weather agency. Drainage systems was also constructed to address flooding. The project was designed in compliance with the National Building and Structural Codes of the Philippines, and internationally accepted guideline. Moreover, Emergency Preparedness and Response Plan will be implemented.

2.1.1.5 Impact in the Existing Land Tenure Issue/s

4DVDI has an existing MPSA No. 322-2010-XIII-SMR under which 4DVDI shall explore, develop and utilize for commercial purposes nickel and other associated minerals within the contract area of approximately 1,352.3857 ha (amended) located in Claver, Surigao del Norte and Carrascal, Surigao del Sur, within Parcel I of the Surigao Mineral Reservation (**Figure 2.1.2**).

On September 18, 2020, the MPSA No. 322-2010-XIII-SMR was transferred to 4DVDI from 4DVDI under a DOA of Mining Rights, as approved by the DENR. The amended MPSA originated from and is a portion of MPSA-322-2010-XIII-SMR of 4DVDI, which was permitted by the DENR on February 11, 2010, with an area of 2,320.088 ha.

Data provided by National Commission on Indigenous Peoples (NCIP) showed that Certificate of Ancestral Domain Titles (CADT) covers few parcels (i.e. northwest and east) of the proposed project site. However, there are no Comprehensive Agrarian Reform Program (CARP) communities, Certificate of Ancestral Domain Claim (CADC), or Certificate of Ancestral Land Claim (CALC) within or surrounding the project site as per DENR accounts.

Besides, MPSA No. 322-2010-XIII-SMR does not have any overlap with other mine tenements per MGB Region XIII (CARAGA) records. 4DVDI will coordinate with key government and local agencies such as the DENR, MGB, the Carrascal LGU, local NCIP, and IP leaders/ representatives to apply and/or renew relevant permits. Potential overlaps with areas not covered by the existing MPSA will be secured through joint ventures or agreements with the legal entities that have jurisdiction over the properties.

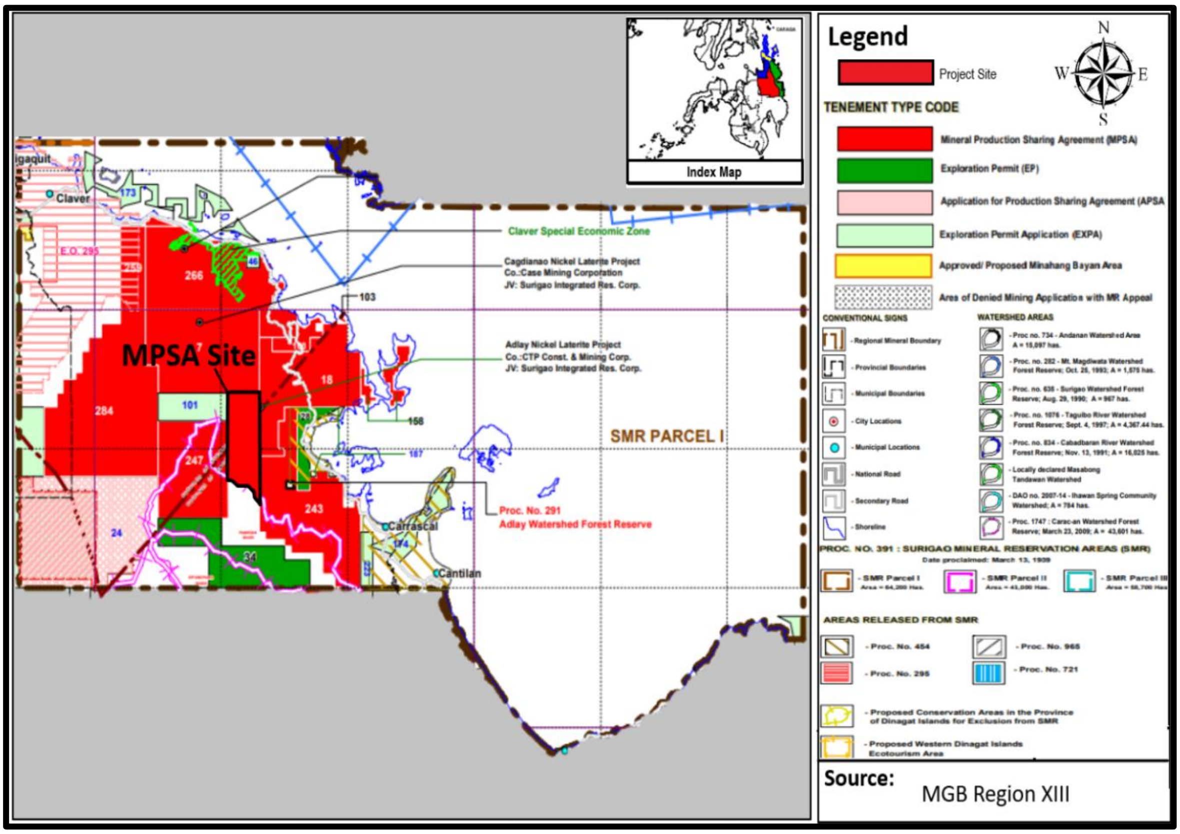


Figure 2.1.2: Tenements Map in relation to Project Site

2.1.1.6 Impairment of Visual Aesthetics

The proposed location of the proposed project will be largely in Barangays Pantukan and Adlay, Carrascal, Province of Surigao del Sur. **Figure 2.1.3** shows several mining parcels of CTP Mining Corp. occupies the northern-northeastern part of the MPSA. Vast shrubland and grassland parcels covering terrain that range from moderate to high sloping occupy the mid-section and western flank of the project site. Facing south is Pantukan River while the eastern side offers a view of the portion of Carrascal Bay and several built-up areas, which are mostly residential types.

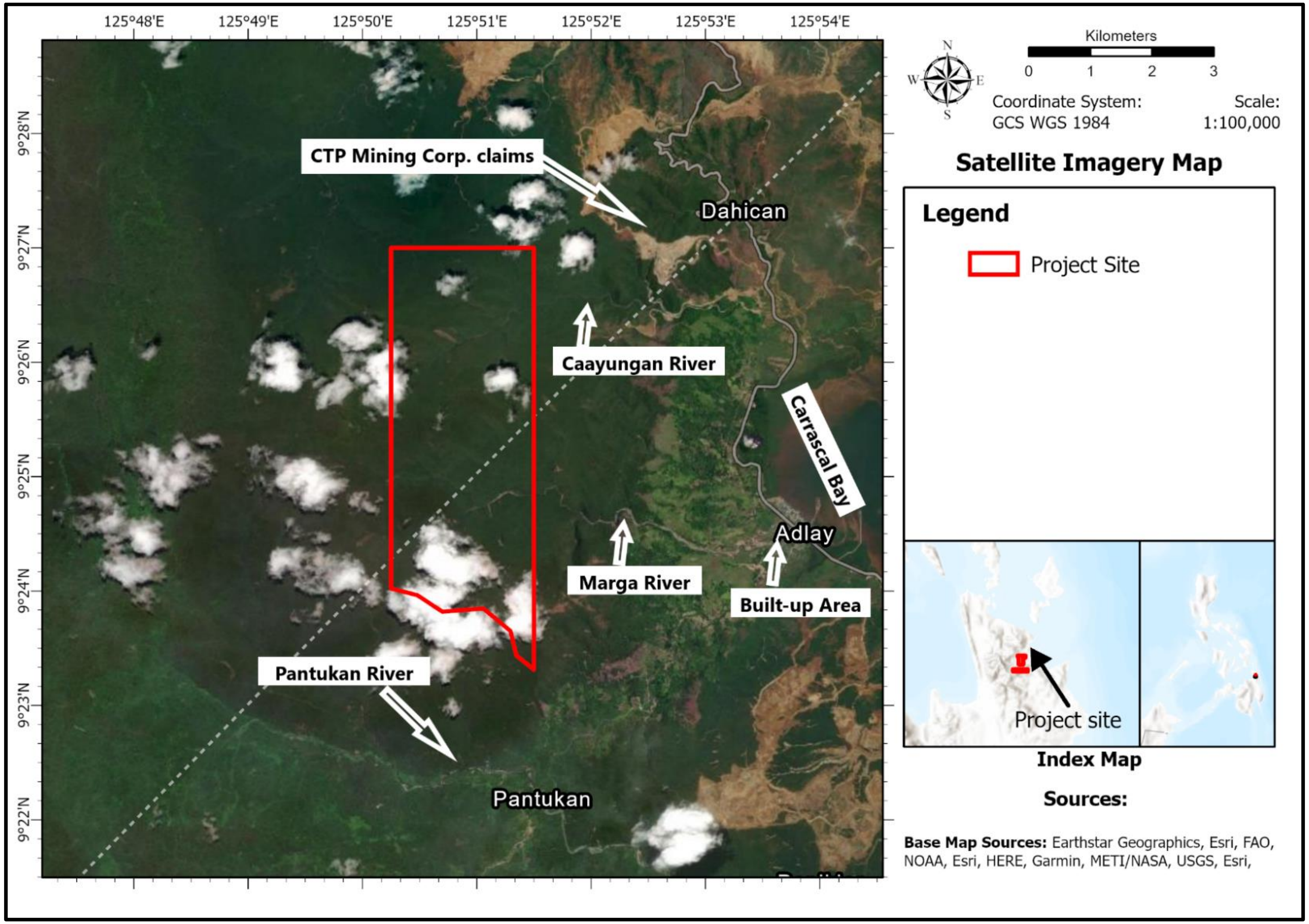


Figure 2.1.3. Satellite Imagery Map of Project Site and Vicinity

Plates 2.1.1 to 2.1.3 presents the actual photos of areas surrounding the proposed project site.

Plate 2.1.1: East of Project Site - the Marga River and Few Built-Up Areas

Plate 2.1.2: Perspective facing East-Northeast of the Project Site - Shrubs and Various Trees Dominated Parcels on Both Sides; the Carrascal Bay on the Far Northeast

Plate 2.1.3: South of Project Site - Pantukan River and Forestland Covering Terrain

Nickel extraction requires an open-pit method of mining. Stockpiles and overburden/ waste piling will have a negative effect on the landscape by causing visual intrusion. Activities such as drilling and excavation usually affect the original landscape of the area leaving behind depressions and a potential point of collecting water forming artificial ponds.

To minimize these aesthetic impairments, 4DVDI will take into consideration the existing landforms and vegetative cover in siting before drilling and excavation; locate stockpiles, overburden/ waste, and haul routes away from the sensitive landscape and visual receptors; and will backfill the open pits where applicable using the overburden generated during excavation.

Lastly, rehabilitation strategies and final land use for mine closure will be discussed and consulted with the affected stakeholders as part of the FMRDP process. While the land impacted by mining will not be totally reverted to its original form and state, consultations will be conducted with the stakeholders and further investigations will be directed to determine the most feasible options to rehabilitate the area and convert these areas into landforms that will at least match the surrounding environment and will have an alternative beneficial use.

2.1.1.7 Devaluation of Land Value as a Result of Improper Solid Waste Management and Other Related Impacts

There is no solid waste management system in place in the area as the major anthropogenic activities consists of agricultural and fisheries activities.

The proposed project will involve land clearing, construction of structures, and ore extraction. During operation, the project is expected to generate both hazardous and non-hazardous wastes. If not managed properly, this may cause land and water contamination.

4DVDI and its contractor, 4DVDI, will be responsible for the management of the solid wastes on-site during the construction, development, and rehabilitation of the proposed project. 4DVDI will implement the following solid waste management measures to comply with the Republic Act No. 6969 and avoid contamination of land and water due to improper waste disposal:

- Strict implementation of rules and regulations on sanitation and waste disposal
- Procure and strategically place adequate solid waste collection bins with a capacity for segregation within the site;
- Create awareness through conduct of IEC on best waste management practices among the employees including posting of signage and provision of properly-labelled waste bins;
- Provision of storage area for solid wastes and construction of a temporary MRF
- Non-hazardous wastes will be disposed in the local government disposal area; and
- Hazardous wastes such as used oil, used batteries, busted bulbs, expired chemicals and laboratory wastes will be stored on-site and hauled and treated offsite by a third party DENR-registered waste treater.

2.1.2 Geology/Geomorphology

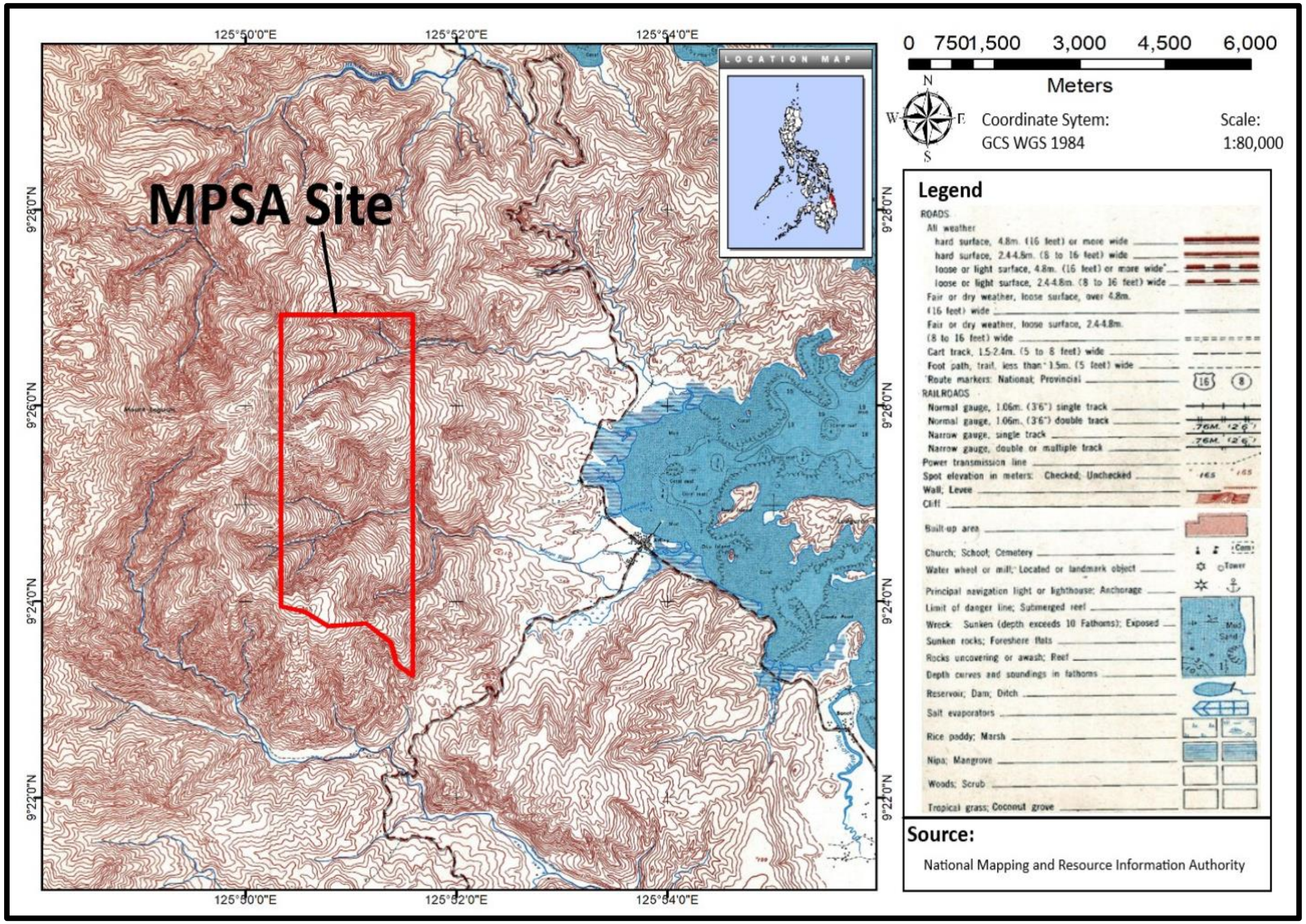
2.1.2.1 Surface Landform/Geomorphology/Topography/Terrain/Slope

The proposed project lies approximately four (4) km west of Carrascal Bay in the Province of Surigao del Norte, Northeast Mindanao.

The project site is drained by dendritic rivers that empty into Carrascal Bay. These rivers are the Marga River that drains the lower half of the project area and the Caayungan River that drains the upper portion of the project area. V-shaped minor streams draining the southwestern portion are connected to the Pantukan River and characterized by narrow channels with steep banks.

The site and immediate vicinity are characterized by mountainous terrains with round ridges, bounded by steep to very steep gradients. The highest elevation is around 1,100 meters above mean sea level (mamsl) located at the southern part of the project area. Slopes within the project area range from steep (30-60%) to very steep (>60%), with some undulating (8-18%) to moderately steep (18-30%) areas in narrow valleys.

Figure 2.1.4, **Figure 2.1.5** and **Figure 2.1.6** present the topographic, elevation, slope, and of the MPSA site and its vicinity, respectively.



Source: NAMRIA Sheet 4148-II (Carrascal Quadrangle)

Figure 2.1.4: Topographic Map of the MPSA Site and Vicinity

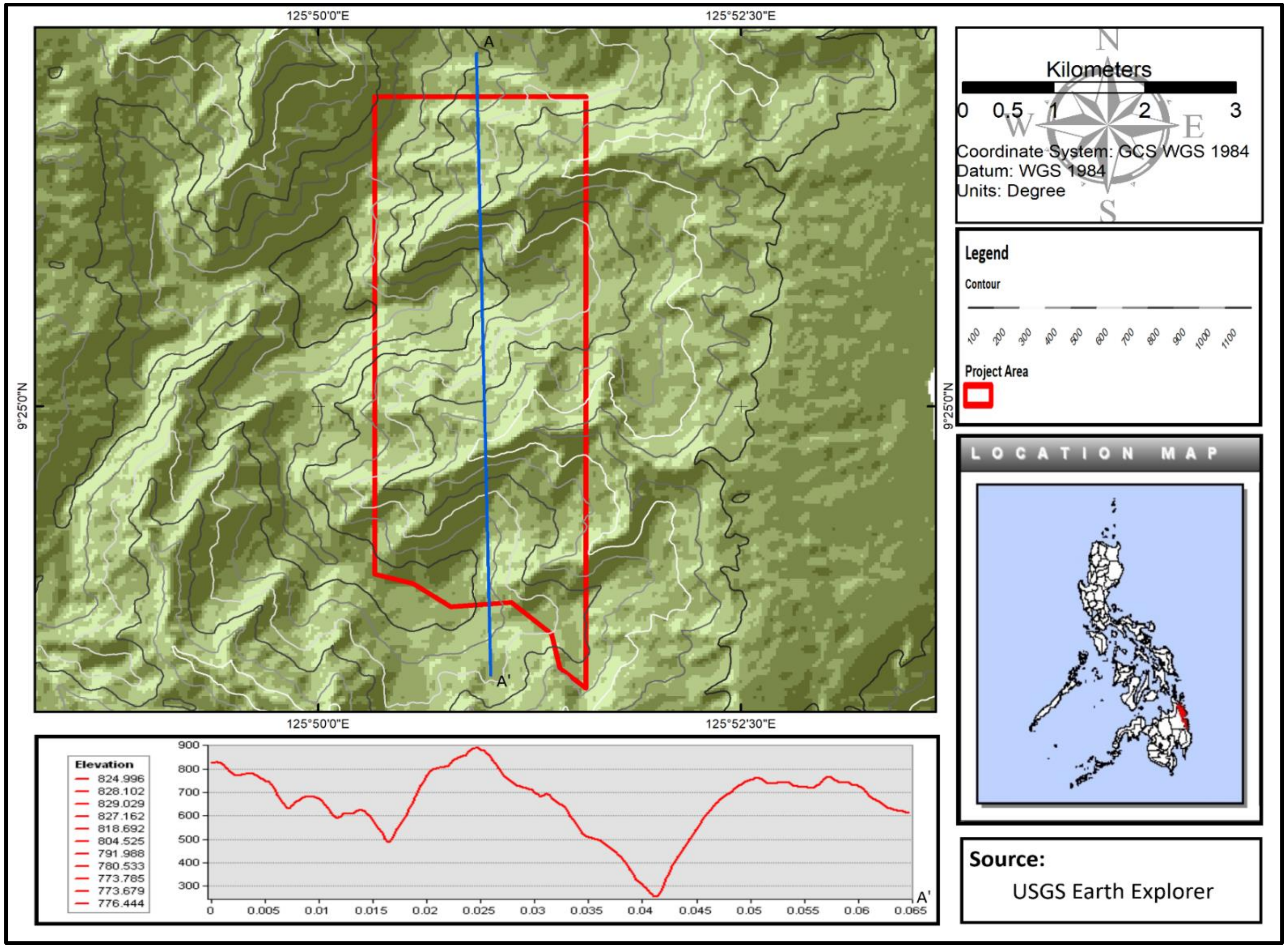


Figure 2.1.5: Elevation Map and Profile of the MPSA Site and Vicinity

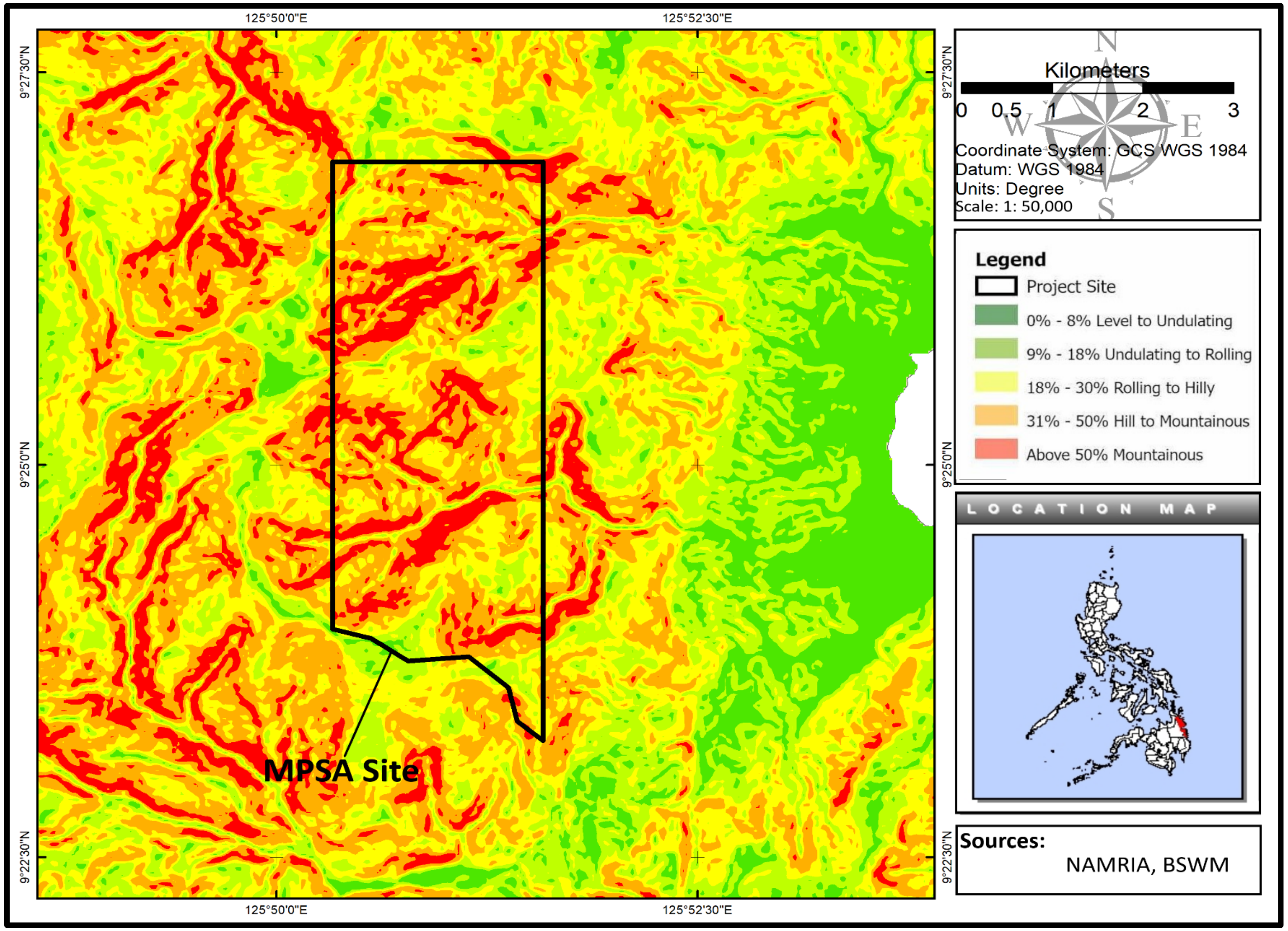


Figure 2.1.6: Slope Map of the MPSA Site and Vicinity

Two (2) major geomorphic units were identified in the project area; namely, Denudational Hills and Slopes (DHS) and Deposited Plains (DP).

Denudational Hills and Slopes

DHS occupies more than 95% of the claims, which include the areas with rolling to rugged topography with a peak of 1,100 mamsl. These areas were subjected to folding and uplifted through tectonic movements. These are underlain by ultramafics that are typically strongly warped and severely fractured. Those with high relief have steeper slopes while those with low relief have smoother slopes.

DHS is covered by residual soil. The soil is composed of the weathering products of different rock units situated in the elevated portions of the study area. Soils here come from ultramafics, clastics and spilites. Texture ranges from medium to coarse and generally silty to gravelly. Based on the vegetative cover observed in the area, the soil has supported the growth of forest trees before but the primary ones are long gone due to logging. There are remnants of trees left in the area but these are mostly clustered in riparian zones and peaks of high mountains where access for loggers is difficult. Secondary forest growth is however robust. In areas underlain by thin soil cover, growth of plants is stunted probably due to the nature of soil, particularly over ultramafic rocks.

Depositional Plain

DP occupies small patches of alluvial fans and valleys in the eastern section and along river systems of the mapped area in **Figure 2.1.7.** The alluvials were mainly formed by the deposition and accumulation of unsorted and unconsolidated clay, silt, sand, pebbles, cobbles and even boulders. The grain sizes are generally rounded and composed of different lithologies consisting mainly of ultramafics. Soil of the clayey type is well formed and derived from the weathering of these transported sediments or alluvial deposits. Slope of the unit is between 0-3° and elevation ranges from 5-10 m.

Occupying a minor portion of the mapped area, the alluvium is located in flat to nearly flat areas and devoted mainly to agriculture. Soil here is a combination of residual and transported types the latter of which was formed through the deposition by streams. Generally, the lowlands possess a clay type of soil with the alluvial plains and river terraces having medium to fine textured soils. Vegetables production is occasionally observed but this is basically underutilized.

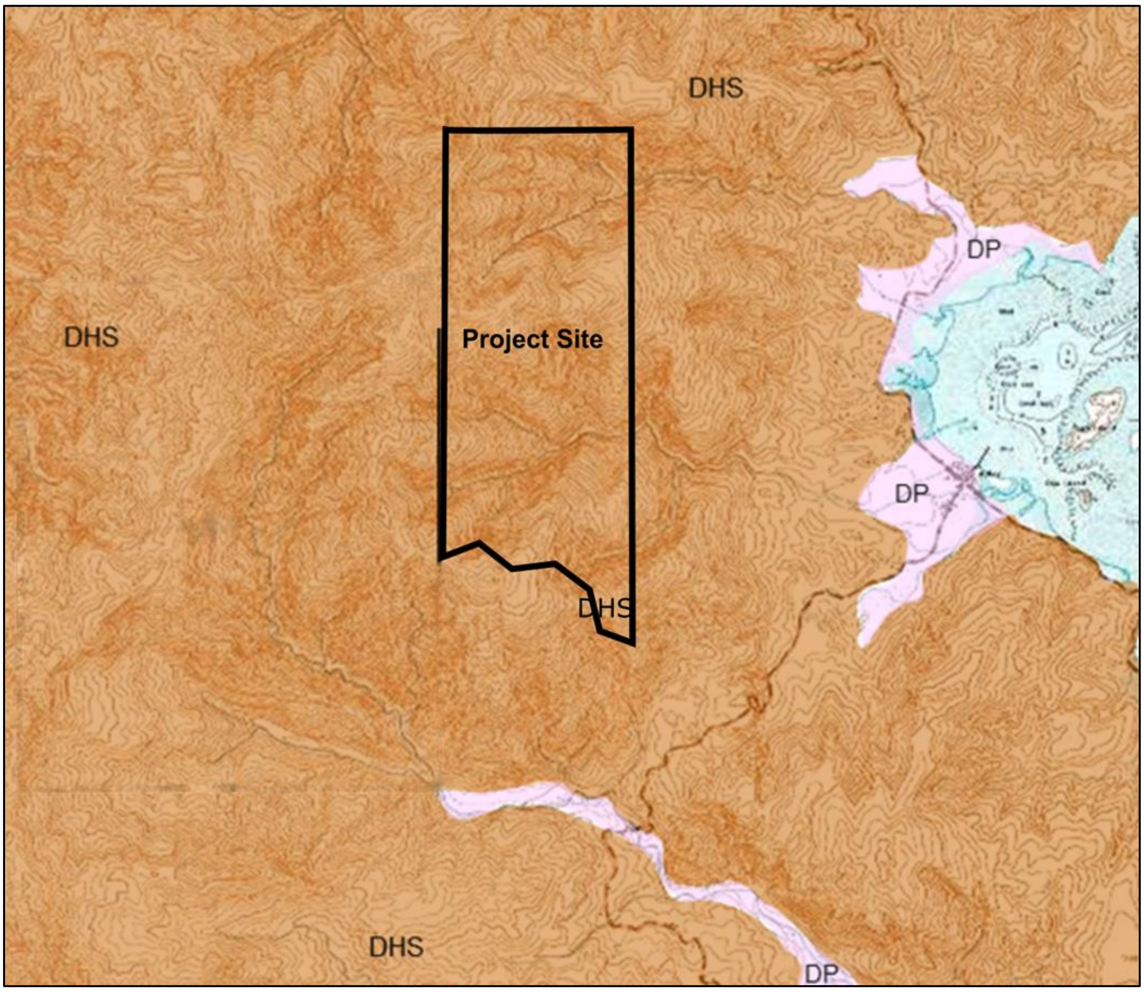


Figure 2.1.7: General Geomorphologic Map of the Project Site

2.1.2.2 Subsurface Geology/Underground Condition

2.1.2.2.1 Regional Geology and Stratigraphy

The formation of an orogenic belt in Eastern Mindanao is considered the most prominent geologic feature in the region. The Mindanao Pacific Cordillera, a more than 400-km NNW-SSE trending mountain range, is bounded by the Philippine Fault on the west and Philippine Trench to the east. It is divided into three sections each having its own distinct terrane. The Northern Pacific Cordillera corresponds to the Surigao Region, the Central Pacific Cordillera coincides with the eroded Surigao del Sur- Agusan region terrain, and the Southern Pacific Cordillera is characterized by steep and topographic terrain of Compostela Valley and Davao Oriental.

Mindanao Island comprises several disparate island arc terranes that became amalgamated probably by the late Cretaceous - early Tertiary. In eastern Mindanao, this amalgamation is marked in part by obducted ophiolitic sheets emplaced on an older volcanosedimentary arc terrane during late Cretaceous to possibly Eocene times. These strata are now overlain by a succession of carbonate and epiclastic strata, younger volcanic and volcaniclastic units, biohermal limestone and Quaternary volcanic products.

The project site belongs to the North Pacific Cordillera of the Mindanao Pacific Cordillera, under the Stratigraphic Grouping 24 of MGB (2010), which represents a magmatic terrane with an ophiolitic segment in the northern section. Stratigraphic descriptions are as follows:

- The basement rocks of the region consists of the Dinagat Ophiolite and the unconformable Sohoton Greenschist. The ophiolite sequence is composed of amphibolite, peridotite, pyroxenite, dunite, gabbro, and gabbro which are regionally serpentinized. These basement rocks are believed to of Cretaceous to Paleocene age (MGB, 2010).

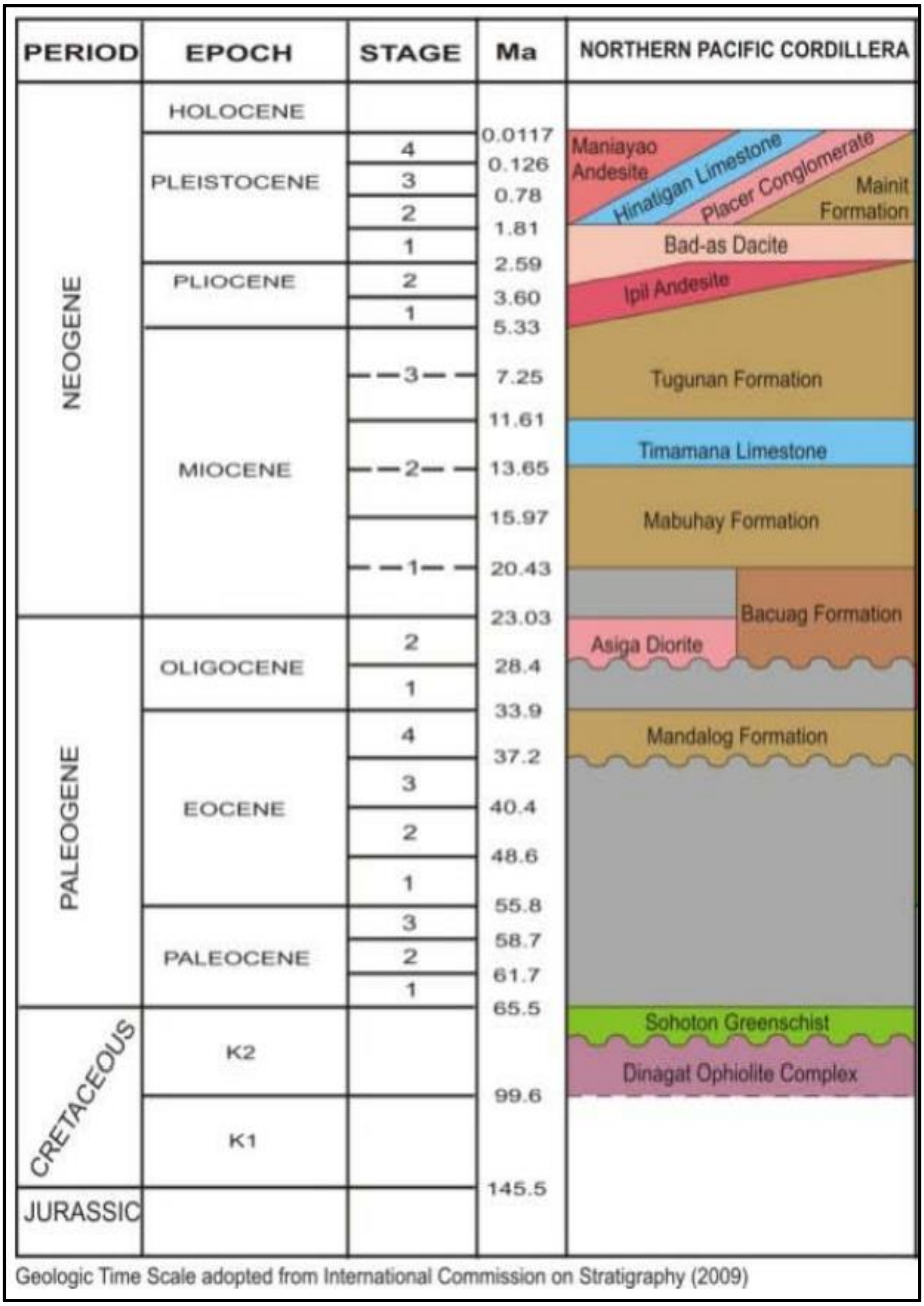
- The basement rocks are unconformably overlain by the *Upper Miocene* Madanlog Formation which is composed of conglomerate, sandstone and shale with limestone lenses. This formation in turn is unconformably overlain by clastic rocks and basalt flows with occasional pillow structures, and agglomerates of the *Late Oligocene to Early Miocene* Bacuag Formation.

- Bacuag Formation is then intruded by Asiga Diorite as well as the *Early to Late Miocene* Alipao Andesite in the vicinities of Alipao and Siana Mine pits.

- Overlying the Bacuag formation is the Mabuhay Formation dated to be of *Early to Middle Miocene* age. The formation consists of interbeded sandstone and mudstone with minor limestone and conglomerate. The *Middle Miocene* Timamana Limestone overlies Mabuhay and Bacuag Formation. This consists of a massive coralline limestone (MGB, 2010). Late Miocene to Late Pliocene Tugunan Formation that overlies Bacuag and Mabuhay Formation as well as Timamana Limestone consists of conglomerate, sandstone and mudstone.

- Intermediate magmatic activity and its associated volcanism during the *Pliocene* produced the reported Andesite Group of Santos et al (1962) and the Andesite Series of Santos-Ynigo (1944). These were further separted by MGB (2010) into the *Early to Late Pliocene* Ipil Andesite, *Late Pliocene* Bad-as Dacite, and the *Pleistocene* Maniayao Andesite.

- *Pleistocene* deposits in the region are the Mainit Formation and Placer Conglomerate, both are dominated by conglomerates and minor sandstones, as well as the Hinatigan Limestone which consists of marl, calcareous wacke, siltstone and limestone.



Source: Geology of the Philippines, Mines and Geosciences Bureau, 2010

Figure 2.1.8: Stratigraphic Column of Northern Pacific Cordillera

2.1.2.2.2 Tectonic Settings

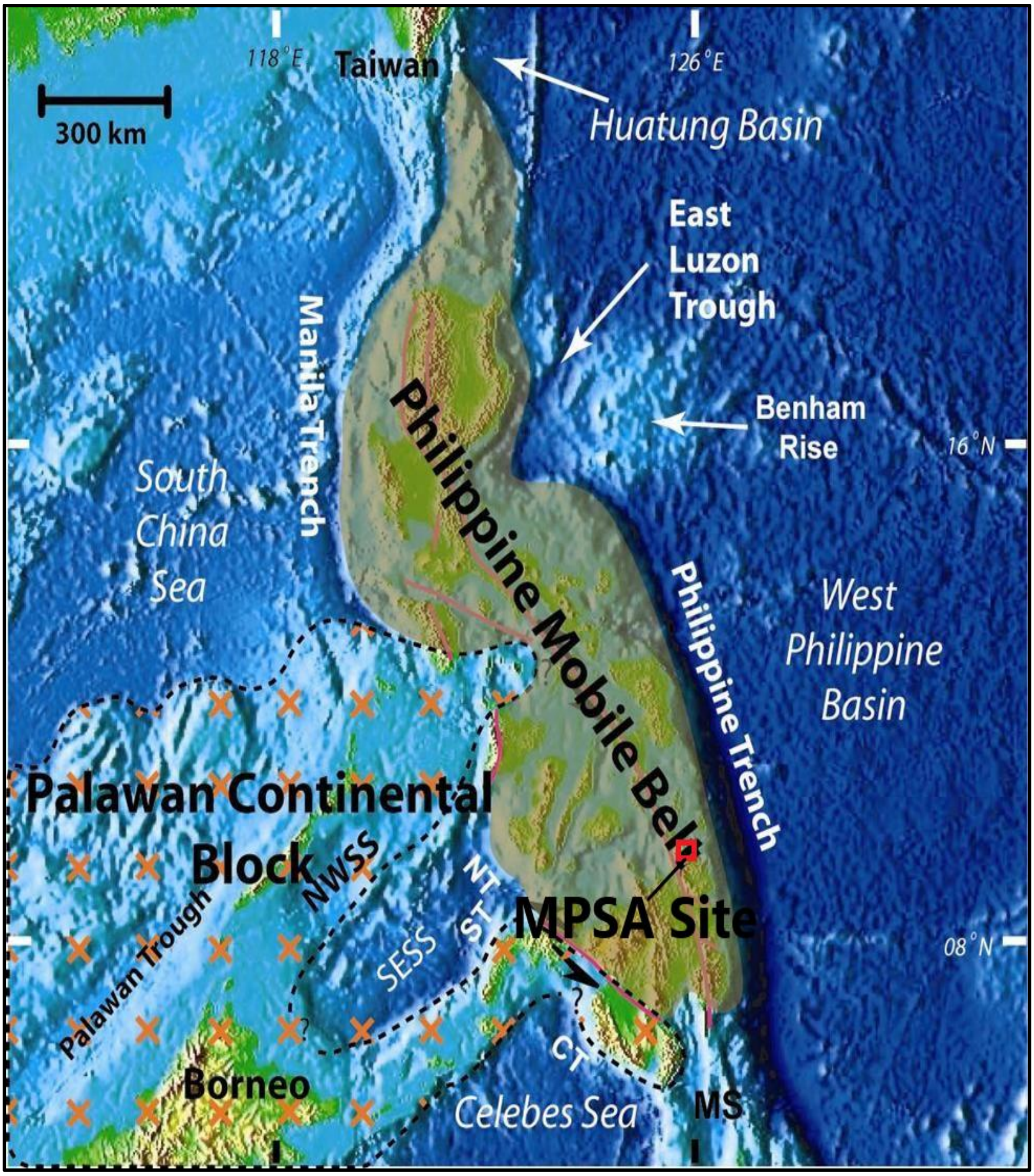
The tectonic setting of the Philippines is unusual in several respects: it is characterized by opposite-facing subduction systems on its east and west sides; the archipelago is cut by a major transform fault, the Philippine Fault; and the arc complex itself is marked by active volcanism, faulting, and high seismic activity. Subduction of the Philippine Sea Plate occurs at the eastern margin of the archipelago along the Philippine Trench and its northern extension, the East Luzon Trough. (Refer to **Figure 2.1.9**).

The East Luzon Trough is thought to be an unusual example of a subduction zone in the process of formation, as the Philippine Trench system gradually extends northward (Hamburger et al., 1983). On the west side of Luzon, the Sunda Plate subducts eastward along a series of trenches, including the Manila Trench in the north, the smaller less well-developed Negros Trench in the central Philippines, and the Sulu and Cotabato trenches in the south (Cardwell et al., 1980). At its northern and southern terminations, subduction at the Manila Trench is interrupted by arc-continent collision, between the northern Philippine arc and the Eurasian continental margin at Taiwan and between the Sulu-Borneo Block and Luzon at the island of Mindoro.

The Philippine fault, which extends over 1,200 km within the Philippine arc, is seismically active. The fault has been associated with major historical earthquakes, including the destructive M7.6 Luzon earthquake of 1990 (Yoshida and Abe, 1992). A number of other active intra-arc fault systems are associated with high seismic activity, including the Cotabato Fault and the Verde Passage-Sibuyan Sea Fault (Galgana et al., 2007).

Relative plate motion vectors near the Philippines (about 80 mm/yr) is oblique to the plate boundary along the two plate margins of central Luzon, where it is partitioned into orthogonal plate convergence along the trenches and nearly pure translational motion along the Philippine Fault (Barrier et al., 1991).

Seismic activity along the boundaries of the Philippine Sea Plate (Allen et al., 2009) has produced 7 great (M>8.0) earthquakes and 250 large (M>7) events. Among the most destructive events were the 1976 M7.6 Moro Gulf and 1990 M7.6 Luzon (Philippines) earthquakes (7,100 and 2,400 casualties, respectively). There have also been a number of tsunami-generating events in the region, including the Moro Gulf earthquake, whose tsunami resulted in more than 5000 deaths.



Source: Dimalanta, et al (2005)

Figure 2.1.9: Tectonic Map of the Philippines

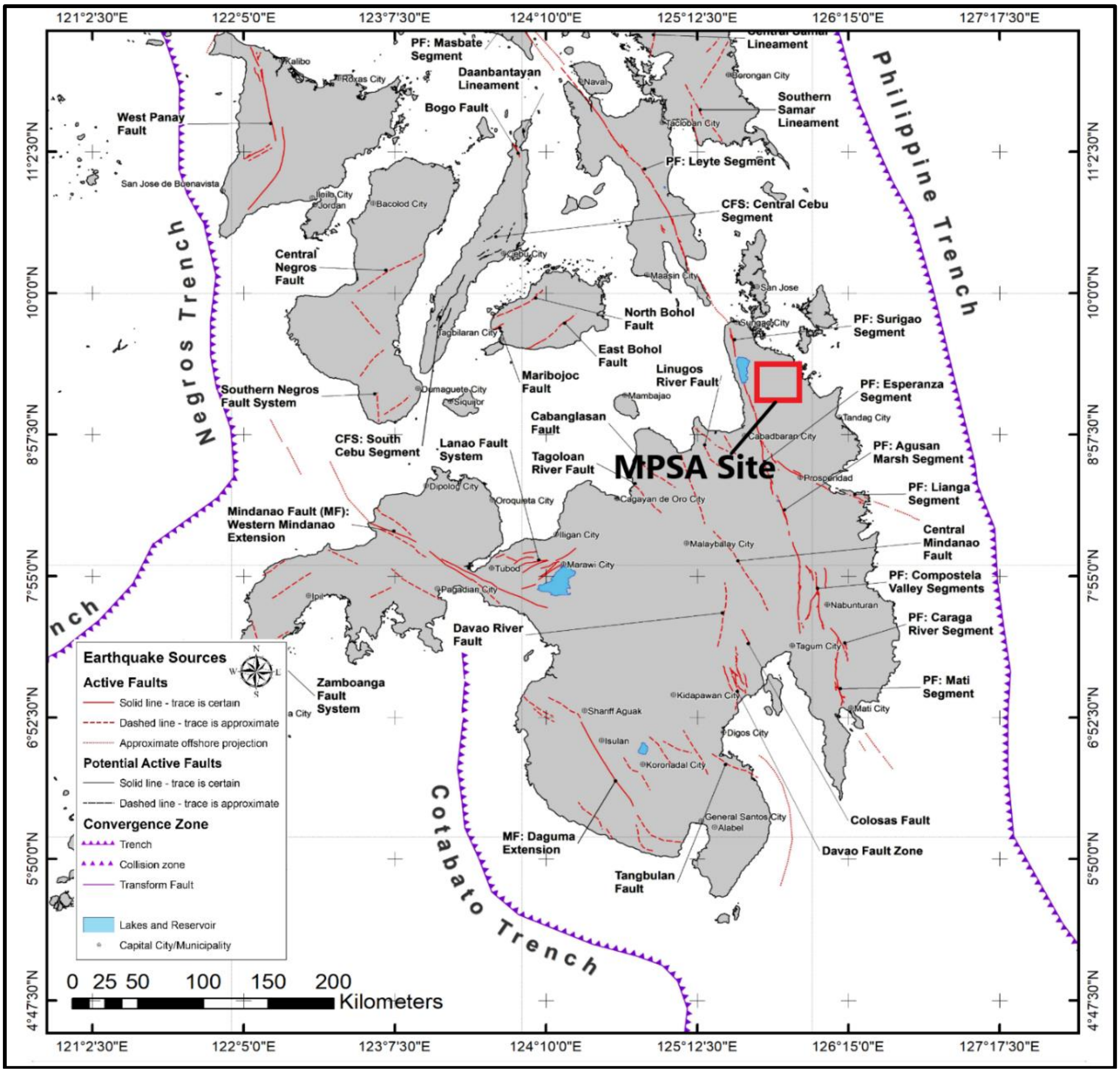
2.1.2.2.3 Regional Tectonic Structures

Structures in the region are mainly influenced by the subduction of the Philippine Sea Plate (PSP) along the Philippine Trench and by the Philippine Fault to the east.

The Philippine Fault Zone, the left-lateral 1,500 km long fault that cuts the Philippine Mobile Belt into two main parts, appears as two parallel faults in Surigao region. It strikes N10°–20°W in Surigao and a relay zone between two of its branches produces a pull a part feature expressed by

Lake Mainit which lies west-northwest of the project area. The project site lies east of the eastern fault that is also called the Surigao Valley Fault (Maglambyan, et al., 2005).

Fold axes of synclines and anticlines are generally oriented northwest southeast as evidence from the systems of fractures observed from the ultramafic rock units. Peridotites are commonly sheared as a result of thrusting when they were emplaced over younger lithologic units. Their boundaries are thrust faults and wide shear zones are common across the units resulting to highly fractured rock mass. Younger tectonic events also contribute to the fracturing of these rocks. **Figure 2.1.10** shows the distribution of active faults and trenches in Mindanao in relation to the project site.



Source: PHIVOLCS-GGRDD, 2018

Figure 2.1.10: Distribution of Active Faults and Trenches in Mindanao in Relation to the Project Site

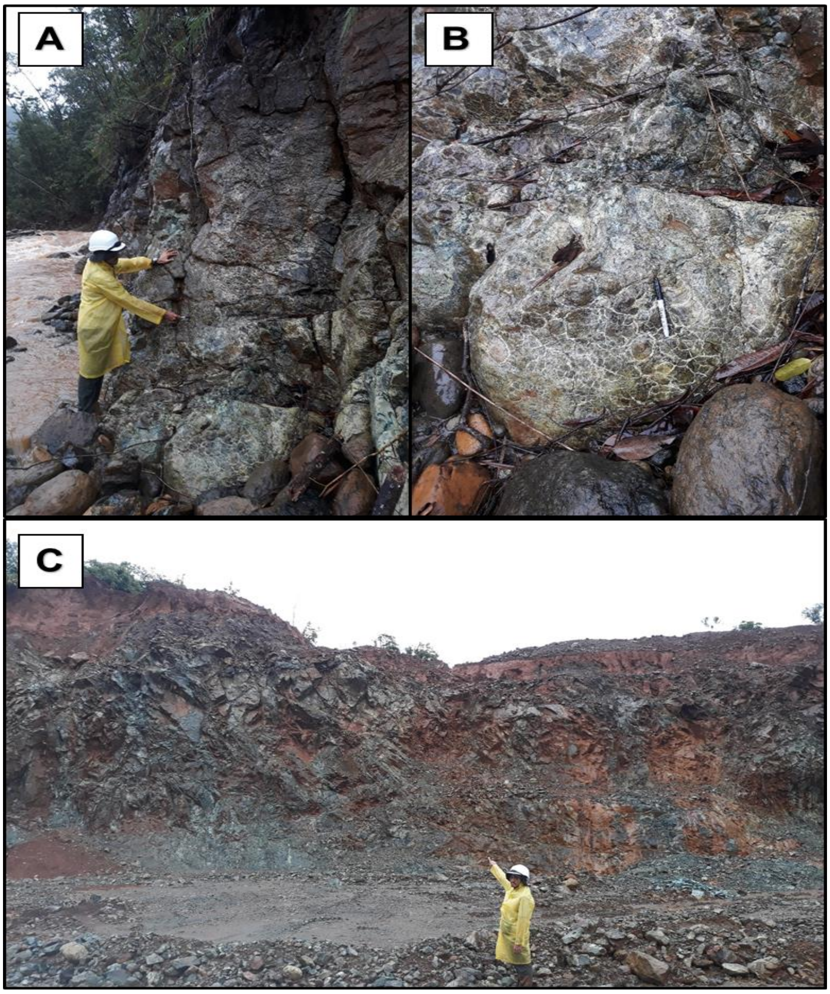
2.1.2.2.4 Site Geology

The geology of the project area consists of ultramafic rocks, laterite, basalts, sandstone, coralline limestone, and Quaternary Alluviums.

The dominant rocks in the project site are mainly ultramafics belonging to the Dinagat Ophiolite (**Figure 2.1.11**). It is mainly composed of harzburgite, dunite, and serpentinite. Serpentinization of ultramafic rocks is evident in the outcrops that were observed in the area (**Plate 2.1.4A-B**). The rocks were also observed to be highly fractured and cut by shear zones (**Plate 2.1.4C**). Redish to brown laterite unit which is the result of the weathering of ultramafic rocks is found along the ridges with gentle to moderate slopes (**Plate 2.1.5**).

Prominent in the locality is metavolcanics specifically spilites. The rock was originally basalts that have been subjected to a certain amount of alteration and transformed into spilites but not completely metamorphosed. Spilite is a fine-grained igneous rock resulting particularly from the alteration of oceanic basalts.

Sedimentary rocks are found near the area composed of sandstone and conglomerate. This mainly corresponds to the Late Oligocene – Early Miocene Bacuag Formation and Early – Middle Miocene Mabuhay formation. Outcrops can be found along the Marga River in Adlay. Timamana Limestone consisting of massive coralline limestone is also widespread in the region covering areas in Surigao del Sur.

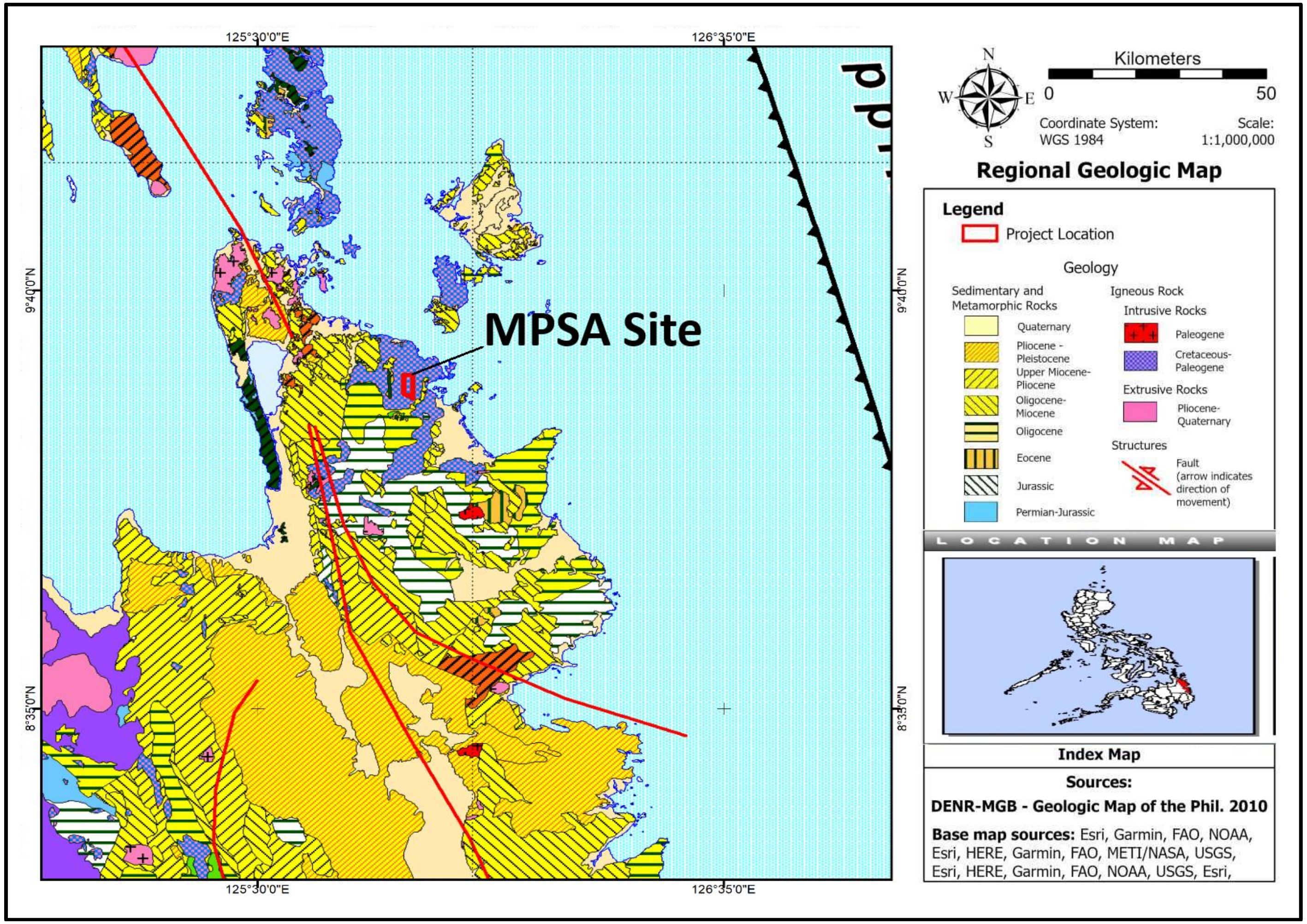


Note: **(A-B)** Outcrop of Dinagat Formation exposed along Caayungan River, northeast of the MPSA site. The outcrop is characterized by massive peridotite traversed by serpentine group minerals. **(C)** Highly fractured ultramafic unit of the Dinagat ophiolite outcropping alongside the access road, northeast of the project site.

Plate 2.1.4: Photographs of Outcrop Present in the Project Site and Vicinity

Note: Ferricretes are the uppermost layer that is almost devoid of nickel after it has been leached down. This unit is equivalent to the red limonite in a laterite profile.

Plate 2.1.5: Deep Red to Reddish Brown Lateritic Units, Mainly Ferricrete, Observed South of the Project Site



Source: Modified after MGB Geologic Map of the Philippines, 2010

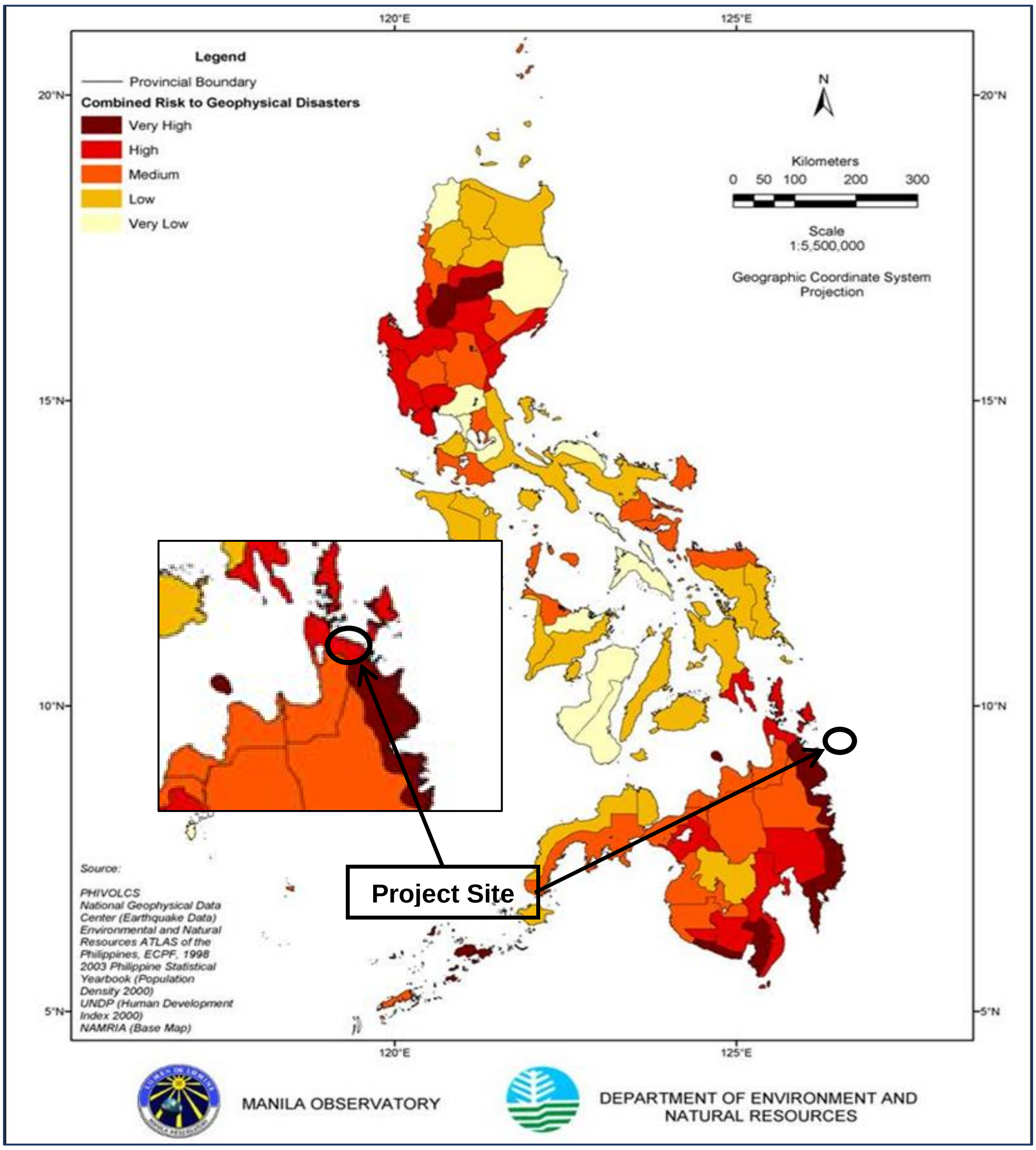
Figure 2.1.11: Geologic Map of the Project Site and Vicinity

2.1.2.2.5 Mineralization

Mineralization in the area is in the form of nickel-bearing laterite attributed to the in-situ weathering of Ultramafic Rocks belonging to the Dinagat Ophiolite. These Ni-laterites are divided into two zones, the ferruginous limonite zone, and nickel rich saprolite zone. The limonite zone is where the residual concentration of non-mobile elements has reached its maximum value. It is essentially made up of clay and other oxide minerals rich in iron. The limonite in the area is mostly red to brown-red. The lower saprolite zone is characterized by active chemical weathering and saprolization of rock. It is mostly made up of rocks and clay in silicate form.

2.1.2.3 Geologic and other Natural Hazard

The Combined Risk to Geophysical Disasters Map presented in **Figure 2.1.12** shows that the project site has high susceptibility to the combined risk to geophysical disasters.



Source: DENR/MO

Figure 2.1.12: Map showing the Combined Risk to Geophysical Disasters

2.1.2.3.1 Seismicity

Based on the Earthquake Hazards Assessment of PHIVOLCS-GGRDD (**Annex 2-1**), the most prominent geohazard recognized in the project site and vicinity is the seismic hazard due to the presence of the following active faults (**Figure 2.1.13**):

Philippine Fault (PF): Surigao Segment --- 34 aerial-km southwest of site (Jabonga Area)
Philippine Trench --- 120 aerial-km east of site
PF: Esperanza Segment --- 63 aerial-km south of site
PF: Lianga Segment --- 88 aerial-km south of site
Central Mindanao Fault --- 141 aerial-km southwest of site

Philippine Fault Zone (PFZ)

The 1,200 km-long PFZ, a major strike-slip fault extending from Lingayen to Davao, lies parallel to the subduction trenches. The PFZ is assumed to release the shear stress caused by the oblique subduction of the oceanic plates. On the southwest, the seafloor of the Sulu Plate subducts near the west side of Negros Island along the Negros Trench and along Sulu Trench near the northwest side of Zamboanga. The Celebes Sea Plate subducts near the west side of Central Mindanao along the Cotabato Trench and in Davao Gulf along the Davao Trench.

The movement of the PFZ produced the majority of the shallow (hypocenter depth) and high magnitude earthquakes in the Philippine history including the most recent 10 February 2017 earthquake event. This earthquake generated from the PFZ's Mindanao segment, the Surigao Valley Fault, was recorded at Ms 6.7. Its nearest splay the Surigao Fault (Jabonga area) is about 34-kilometers southwest of the project site.

Philippine Trench

The Philippine Trench, found about 120 aerial km east of the project site, is a 1,320-km long submarine trench system, which extends from the center of Luzon to the northern Maluku Island of Halmahera in Indonesia (Deschamps, 2003). The Philippine Trench represents the morphologic expression of the subduction of the oceanic crust of the Philippine Sea Plate (PSP) beneath the Philippine Mobile Belt (Lallemand and others, 1998; Ye and others, 2012). Pubellier et al. (1996) suggested that the Philippine Trench (PT) and the Philippine Fault (PF) coupled together and propagated from the north to the south, which is also supported by Aurelio (2000) who pointed out that the PT-PF system formed under a shear partitioning mechanism accompanied with the transformation of the relative movement of the PSP with respect to the Eurasian Plate from a northward to a northwestward motion.

In addition, PT is an elongated bathymetric depression that reaches depths of 10,540 m (Galathea Depth) in the latitude of northeastern Mindanao (Deschamps and others, 2003). Bautista and Oike (2000) describe the Philippine Trench as a region where there is no record of great earthquake activity dating back to 1600, and there is large uncertainty in the seismic potential.

The possibility exists that a strong, near surface earthquake may be generated from the above seismic generators and may cause some impact to the MPSA area and vicinities. This is considered in the hazard assessment under Ground Acceleration. Other earthquake related hazards such as ground shaking, ground rupture, liquefaction, and subsidence, and their direct impact on the project site are discussed in the succeeding sections.

In the past, the Seismological Observation and Earthquake Prediction Division of the Philippine Institute of Volcanology and Seismology (PHIVOLCS-SOEPD) have recorded multiple minor, light, moderate and strong earthquakes within and surrounding the area.

Table 2.1.3 shows selected felt earthquakes (intensity) in CARAGA and vicinities with surface magnitudes (M>5.0) earthquakes provided by PHIVOLCS. Early intensity ratings are evaluated using the nine-point a dapted Rossi-Forel Scale (RF) until 1994 when the new ten-point PHIVOLCS Earthquake Intensity Scale (PEIS) was introduced.

Figure 2.1.14 shows earthquake locations from 1911 to 2017 with magnitude greater than 5.0 and above in the CARAGA region derived from the reviewed PHIVOLCS Earthquake Catalogue. While **Figure 2.1.15** presents 2018 to March 2021 earthquake locations derived from the PHIVOLCS website where parameters are subject for recalculation once the ongoing consolidation of available data becomes complete.

Table 2.1.3: Historical Earthquakes within CARAGA and Vicinity

Year	Depth (km)	Ml	Mb	Ms	Intensity Reports
1911	33			7.7	
1919	33			7.2	
1921	33			7.5	
1922	50			6.7	
1924	33			7.3	
1971	54		5.1		BISLIG RF5 EASTERN MINDANAO RF4
1972	58		5.1		SURIGAO RF2
1973	81		5.3		SURIGAO RF4 HINATUAN RF1
1973	68		5.8		HINATUAN & SURIGAO R3; CAGAYAN DEORO RF2
1973	39		5.7		SURIGAO RF3
1973	46		5.2		SURIGAO RF3
1973	33		5.4		SURIGAO AND CEBU CITY RF2
1973	82		5.5		SURIGAO RF4; CAGAYAN DE ORO RF3; HINATUAN RF2
1975	69	5.5			HINATUAN RF6; MALAYBALAY RF4
1977	50	5.8			GUIUAN BORONGAN SURIGAO RF3; TACLOBAN CATBALOGAN CATARMAN RF2; HINATUAN RF1
1978	33	5			HINATUAN RF3
1980	11	5.4			RF3-TANDAG HINATUAN AND SURIGAO; RF2-GUIUAN
1980	50	5.4			RF5-SURIGAO; RF4-HINATUAN; RF3-CAGAYAN DE ORO AND DAVAO; RF2-BUTUAN
1985	78	5.4			RF5-BISLIG; RF4-HINATUAN; RF2-MALAYBALAY
1989	33	5.8	6.2	6.6	RF7 - BISLIG SURIGAO DEL SUR; RF6-DAVAO CITY; RF5 - COTABATO & CAGAYAN DE ORO CITY; RF3 - PALO LEYTE & CEBU
1990	39		5.6	5.5	INTENSITY IV - BISLIG SURIGAO DEL SUR & CAMIGUIN ISLAND; INTENSITY II - COTABATO CITY
1993	11			6.6	BISLIG RF5 DAVAO RF5; KIDAPAWAN RF4 CAAGAYAN DE ORO RF4 PALO LEYTE RF3 COTABATO RF3 CAMIGUIN ISLAND RF2
1993	8			5.7	BISLIG RF3
1993	18			5.1	BISLIG RF2
1994	3			6.2	INTENSITY VII - HINUNANGAN HINUNDAYAN ANAHAWAN SAN JUAN & ST BERNARD S LEYTE; INTENSITY VI - LIBAGON SILAGO LEYTE; INTENSITY V - SOGOD; INTENSITY IV - ABUYOG LEYTE; INTENSITY III - PALO LEYTE; INTENSITY II - SURIGAO
1996	32			5	SURIGAO RF2
1996	12			5.5	BISLIG RF3; SURIGAO CITY RF3
1996	18			5.2	BUTUAN CITY RF3; SURIGAO CITY RF2; HINATUAN RF2; BISLIG RF2
1996	17			5.4	SURIGAO CITY RF3; TACLOBAN CITY RF2
1996	22			5.2	SURIGAO CITY RF2; PALO LEYTE RF1
1996	33			5.2	SURIGAO CITY RF3; BISLIG SURIGAO DEL SUR RF3
1996	23			5.4	SURIGAO CITYRF3; BUTUAN CITY RF3; PALO LEYTE RF1
1996	12			5.9	SURIGAO CITY RF3; BUTUAN RF3; PALO RF3; DAVAO RF2; BISLIG RF2
1996	58			6.3	SURIGAO CITY RF4; BISLIG CAGAYAN DE ORO PALO LEYTE RF3; LAPU-LAPU RF2; TAGBILARAN RF2; DAVAO CITY RF2
1996	21			5.8	SURIGAO CITY RF2
1996	19			5	SURIGAO CITY RF2
1996	7			6	SURIGAO CITY RF3; BUTUAN CITY RF2
1996	224			6.2	BUTUAN CITY RF5; SURIGAO CITY RF3; PALO LEYTE RF3
1996	5			5.2	SURIGAO RF3; BISLIG RF3
1997	18			5.3	INTENSITY II - SURIGAO CITY
1997	100			6.7	INTENSITY V - BISLIG SURIGAO DEL SUR; MATI DAVAO ORIENTAL; INTENSITY IV - DAVO CITY; TAGUM DAVAO DEL NORTE; CAGAYAN DE ORO CITY;

Year	Depth (km)	Ml	Mb	Ms	Intensity Reports
					INTENSITY III - SURIGAO CITY BUTUAN CITY; INTENSITY II - GENERAL SANTOS CITY; INTENSITY I - CAMIGUIN
1997	23			5	INTENSITY III - BISLIG SURIGAO DEL SUR; INTENSITY I - SURIGAO CITY
1997	3			5.2	INTENSITY II - SURIGAO CITY
1997	15			5.5	INTENSITY III - SURIGAO CITY; INTENSITY II - PALO LEYTE
1997	31			5.2	INTENSITY III - BISLIG SURIGAO DEL SUR
1997	19			5.3	INTENSITY III - SURIGAO CITY; INTENSITY II - PALO LEYTE
1997	42			5.9	INTENSITY V - BISLIG SURIGAO FEL SUR; INTENSITY IV - BUTUAN CITY; INTENSITY III - DAVAO CITY; SURIGAO CITY; CAGAYAN DE ORO CITY; HIBOK-HIBOK CAMIGUIN; INTENSITY II - PALO & SOGOD LEYTE
1997	19			5	INTENSITY III - SURIGAO CITY
1997	21			5.2	INTENSITY III - SURIGAO CITY; INTENSITY II - PALO LEYTE AND LAPU-LAPU CITY
1997	140			6.6	INTENSITY V - SURIGAO CITY BUTUAN CITY; INTENSITY IV - BUKIDNON HIBOK-HIBOK; DIPOLOG; BISLIG PROPER; INTENSITY III - TABON BISLIG; PALO LEYTE; LAPU-LAPU CITY; CEBU CITY; MANDAUE TAGBILARAN GENERAL SANTOS DAVAO CAGAYAN DE ORO CITY; INTENSITY I - KIDAPAWAN CITY
1998	21			5.9	INTENSITY VI -SOGOD S. LEYTE INTENSITY IV - PALO & TACLOBAN LEYTE INTENSITY III LAPU-LAPU SOGOD SOUTHERN LEYTE VI PALO TACLOBAN IV LAPU-LAPU CITY CABAGNAAN NEGROS OCCIDENTAL III SURIGAO CITY II
1999	7			5.1	INTENSITY VII - BAYUGAN AGUSAN DEL SUR; INTENSITY V - SAN FRANCISCO AGUSAN DEL SUR BUTUAN CITY; INTENSITY IV - HINATUAN SURIGAO DEL SUR; INTENSITY II - LIANGA BISLIG SURIGAO DEL SUR CAGAYAN DE ORO CITY
1999	14			5	INTENSIYT VI - TALACOGON AGUSAN DEL SUR; INTENSITY V - BAYUGAN AS INTENSITY IV - HINATUAN AS; BUTUAN CITY; BISLIG; INT III - SAN FRANCISCO AS PROSPERIDAD AS
1999	4			6	INTENSITY IV - SURIGAO PALO; INTENSITY III - BISLIG BUTUAN HIBOK-HIBOK; INTENSITY II - CAGAYAN DE ORO CEBU DUERO BOHOL INTENSITY I - DIPOLOG CITY
1999	3	5.2	6.2	5.8	INTENSITY I - BISLIG
2000	19	4.7	5.7	5	INTENSITY II - SURIGAO INTENSITY I - BISLIG
2000	17	5.2	6.1	5.7	INTENSITY II - SURIGAO CITY
2000	25	5	5.9	5.5	INTENSITY II - SURIGAO CITY
2000	2	4.7	5.7	5.1	INTENSITY II - SURIGAO CITY
2000	12	4.9	5.9	5.4	INENSITY V - SURIGAO; INTENSITY III - BUTUAN; INTENSITY I- CAMIGUIN
2001	1	4.9	5.8	5.3	INTENSITY III - PALO LEYTE INTENSITY II- SURIGAO CITY
2003	14	4.6	5.6	5	BISLIG INTENSITY I
2004	2	5.1	6	5.7	INTENSITY V - TAGUM CITY INTENSITY III - BISLIG DAVAO INTENSITY II - KIDAPAWAN BUTUAN
2004	1	4.7	5.7	5	INTENSITY III - COMPOSTELA VALLEY INTENSITY II- BISLIG
2004	15	4.6	5.6	5	INTENSITY III - BISLIG SURIGAO DEL SUR
2005	27	4.6	5.6	5	INTENSITY III - SURIGAO CITY
2005	48	4.7	5.7	5.1	INTENSITY III - BUTUAN CITY; INTENSITY I - SURIGAO CITY
2005	11	4.9	5.8	5.3	INTENSITY III - BUTUAN CITY; INTENSITY II - CAGAYAN DE ORO CITY; BISLIG
2006	69	4.8	5.8	5.3	INTENSITY III - BISLIG SURIGAO DEL SUR INTENSITY II - BUTUAN CITY INTENSITY I - CAMIGUIN ISLAND
2007	39	4.7	5.7	5.2	INTENSITY IV - SOCORRO SURIGAO DEL SUR INTENSITY III TANDAG CARRASCAL SURIGAO DEL SUR BUTUAN CITY INTENSITY II - CAGAYAN DE ORO CITY CEBU CITY
2007	49	4.8	5.8	5.3	INTENSITY III - SURIGAO CITY; INTENSITY II - BISLIG SURIGAO DEL SUR
2007	93	4.8	5.7	5.2	INTENSITY II- BISLIG SURIGAO DEL SUR; INTENSITY I- BUTUAN DAVAO CITY
2007	19	4.6	5.6	5	BISLIG SURIGAO DEL SUR - INTENSITY IV
2007	5	4.9	5.8	5.4	INTENSITY IV - GENERAL LUNA SIARGAO; INTENSITY III - DAPA SURIGAO CITY; CABADBARAN AGUSAN DEL NORTE; INTENSITY II - BISLIG SURIGAO
2008	62	4.6	5.6	5	INTENSITY III - BISLIG SURIGAO DEL SUR
2008	5	5.1	6.1	5.7	INTENSITY VI - ST BERNARD S. LEYTE; INTENSITY V - HILONGOS; SOGOD S. LEYTE; INTENSITY IV - SURIGAO CITY
2008	83	4.8	5.8	5.3	INTENSITY II - BISLIG CITY
2009	25	5.2	6.2	5.8	INTENSITY IV - HINATUAN SURIGAO DEL SUR; INTENSITY III - MATI; INTENSITY II - DAVAO CAGAYAN DE ORO; MANAY DAVAO ORIENTAL; NABUNTURAN COMPOSTELA VALLEY; BUTUAN CITY

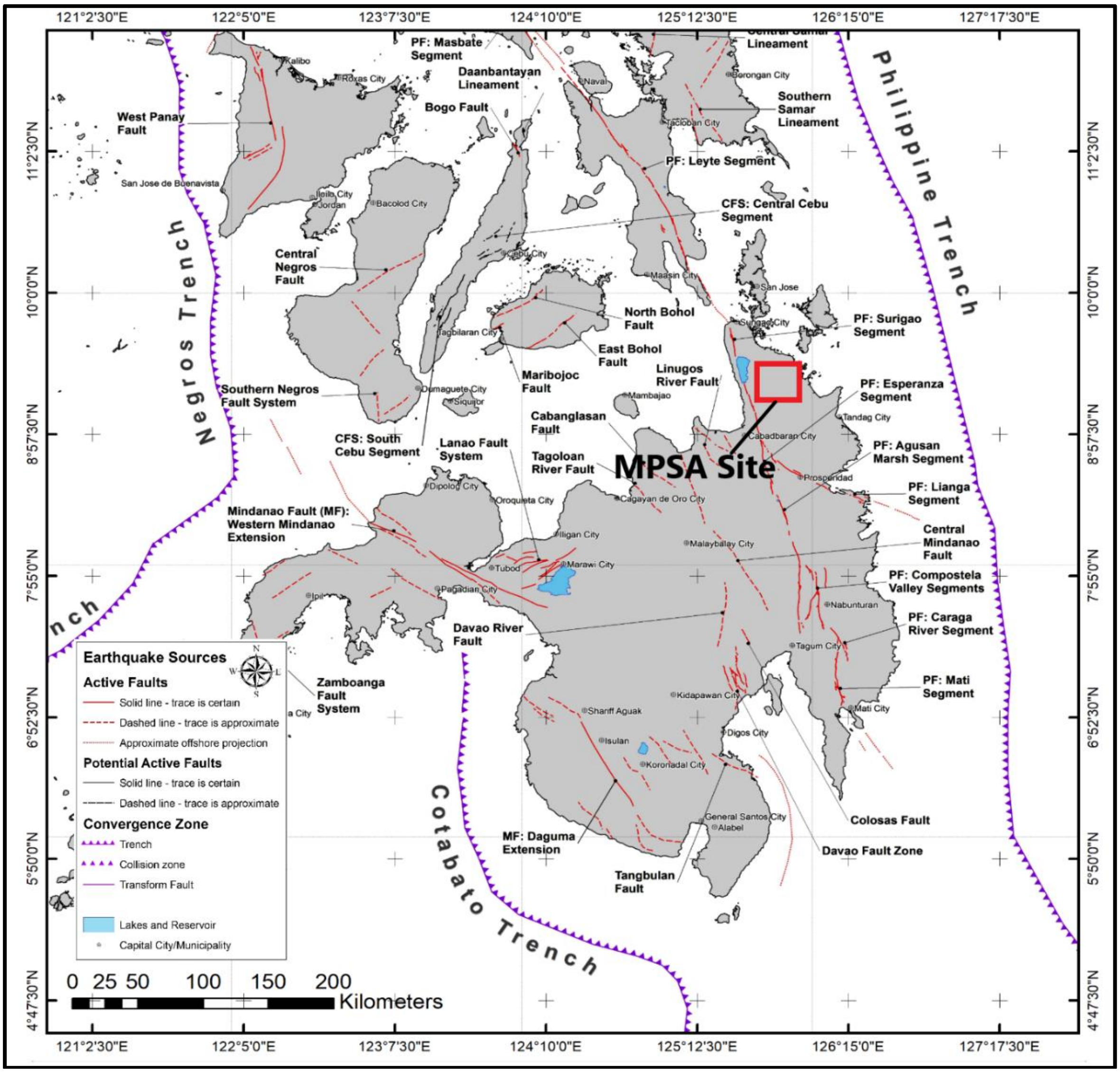
Year	Depth (km)	Ml	Mb	Ms	Intensity Reports
2009	16	5.2	6.1	5.8	INTENSITY VI - BUTUAN CITY; INTENSITY IV - SURIGAO CITY; INTENSITY III - CAGAYAN DE ORO CITY; BASILISA DINAGAT ISLAND; TAGOLOAN MISAMIS ORIENTAL; TANDAG SURIGAO DEL NORTE; COMPOSTELA VALLEY; HINATUAN SURIGAO DEL SUR; HINUNANGAN SOUTHERN LEYTE; INTENSITY II - DAVAO CITY; TACLOBAN CITY; CEBU CITY; GENERAL LUNA SIARGAO ISLAND; CAMIGUIN ISLAND; INTENSITY I - BISLIG CITY
2009	84	4.7	5.7	5.1	INTENSITY II - SURIGAO CITY
2010	10	4.6	5.6	5	INTENSITY IV - TANDAG SURIGAO DEL SUR; INTENSITY III - LINGIG SURIGAO DEL SUR; SAN FRANCISCO AGUSAN DEL SUR; INTENSITY II - BISLIG SURIGAO DEL SUR; BAROBO SURIGAO DEL SUR; BUTUAN CITY
2010	35	4.6	5.6	5	INTENSITY IV - DINAGAT ISLAND SAN JOSE; INTENSITY III - PILAR SIARGAO ISLAND; INTENSITY II - SURIGAO CITY
2010	14	5.1	6	5.6	INTENSITY IV - BURGOS SIARGAO SURIGAO DEL NORTE; INTENSITY III - SURIGAO CITY; DEL CARMEN SIARGAO SURIGAO DEL NORTE; INTENSITY II - HINUNANGAN AND HINUNDAYAN SOUTHERN LEYTE
2010	4	4.7	5.7	5.1	INTENSITY IV - SAN ISIDRO SURIGAO DEL NORTE; INTENSITY II - SURIGAO CITY; SOCORRO SURIGAO DEL SUR
2011	3	5.1	6	5.7	INTENSITY VII - CARRASCAL AND CANTILAN SURIGAO DEL SUR; INTENSITY V-CLAVER SURIGO DEL NORTE; MADRID SURIGAO DEL SUR; INTENSITY IV - CARMEN SURIGAO DEL SUR; INTENSITY III - BUTUAN CITY; BUENAVISTA AGUSAN DEL SUR; SOCORRO AND MAINIT SURIGAO DEL NORTE; INTENSITY II - SURIGAO CITY; BISLIG CITY; CORTES SURIGAO DEL SUR; INTENSITY I - CAGAYAN DE ORO CITY
2011	138	4.9	5.9	5.4	INTENSITY IV - DEL CARMEN SIARGAO ISLAND; BASILISA & LORETO DINAGAT ISLAND; INTENSITY III - SURIGAO CITY; LIBJO DINAGAT ISLAND; PILAR SIARGAO ISLAND; INTENSITY II - BUTUAN CITY; MAINIT SURIGAO DEL NORTE; INTENSITY I - TACLOBAN CITY
2011	1	4.6	5.6	5	INTENSITY II - BISLIG CITY SURIGAO DEL SUR
2011	6	4.7	5.7	5.1	INTENSITY III - TANDAG SURIGAO DEL SUR; INTENSITY II - SOCORRO SURIGAO DEL NORTE
2012	1	4.6	5.6	5	INTENSITY V - SAN LUIS AND TALACOGON AGUSAN DEL SUR; INTENSITY III - BUTUAN CITY; PROSPERIDAD AGUSAN DEL SUR; INTENSITY II - BAYUGAN AGUSAN DEL SUR; INTENSITY I - CARRASCAL SURIGAO DEL SUR
2012	191	4.8	5.8	5.3	INTENSITY I - BISLIG CITY; INTENSITY II - BAROBO SURIGAO DEL SUR
2012	18	4.6	5.6	5	INTENSITY IV - DAPA AND GENERAL LUNA SURIGAO DEL NORTE SIARGAO ISLAND; INTENSITY III - SURIGAO CITY; CABADBARAN AGUSAN DEL SUR; INTENSITY II - CARRASCAL SURIGAO DEL SUR; BUTUAN CITY
2012	17	5.3	6.2	5.9	INTENSITY VI - SURIGAO CITY; INTENSITY V - GENERAL LUNA SURIGAO DEL NORTE; BASILISA DINAGAT; SAN RICARDO SOUTHERN LEYTE; INTENSITY IV - CARRASCAL SURIGAO DEL SUR; INTENSITY III - TOLOSA NAD TACLOBAN LEYTE; DAVAO CITY; BISLIG CITY; BORONGAN ORAS SULAT DOLORES EASTERN SAMAR; CATEEL TARAGONA DAVAO ORIENTAL; CAGAYAN DE ORO CITY; CAGWAIT SURIGAO DEL SUR; CATBALOGAN SAMAR; MAASIN AND HINUNANGAN SOUTHERN LEYTE; INTENSITY II - CEBU CITY; BUTUAN CITY; SAN AGUSTIN SURIGAO DEL SUR; INTENSITY I - HIBOK-HIBOK CAMIGUIN
2012	8	4.6	5.6	5	INTENSITY IV - HINATUAN SURIGAO DEL SUR; INTENSITY III- BISLIG SURIGAO DEL SUR
2012	51	6.5	7.3	7.6	INTENSITY VII - GUIUAN ORAS SULTAT GENERAL MAC ARTHUR LLORENTE EASTERN SAMAR; BORONGAN CITY; INTENSITY VI - SAN JULIAN EASTERN SAMAR; PALO LEYTE; SIARGAO ISLAND SURIGAO DEL NORTE; TACLOBAN CITY SURIGAO CITY; SAINT BERNARD HINUNANGAN SOUTHERN LEYTE; BOBON NORTHERN SAMAR; SAN POLICARPO EASTERN SAMAR; KANANGA LEYTE; MATI CITY; COMPOSTELA VALLEY; LEGASPI CITY ILOILO CITY; BISLIG CITY; LINGIG SURIGAO DEL SUR; BUTUAN CITY CARRASCAL BAROBO TANDAG SURIGAO DEL SUR;
2012	32	5.2	6.2	5.8	INTENSITY I - SURIGAO CITY
2012	1	4.9	5.9	5.3	INTENSITY II - TANDAG SURIGAO DEL SUR
2012	37	4.7	5.6	5.1	NTENSITY III - SURIGAO CITY
2012	28	5.7	6.6	6.5	INTENSITY V- TANDAG SURIGAO DEL SUR; GENERAL LUNA SIARGAO ISLAND; INTENSITY IV -SURIGAO CITY; DAPA SURIGAO DEL NORTE; MAGALLANES AND KITCHARAO AGUSAN DEL NORTE; TUBAJON AND CAGDIANAO DINAGAT

Year	Depth (km)	Ml	Mb	Ms	Intensity Reports
					PROVINCE; INTENSITY III - BISLIG CITY; BASILISA AND LIBJO DINAGAT PROVINCE; INTENSITY II - CEBU CITY; DAVAO CITY; SANTIAGO AGUSAN DEL NORTE; MAGSAYSAY MISAMIS ORIENTAL
2013	39			5.2	INTENSITY IV - GENERAL LUNA SURIGAO DEL NORTE; INTENSITY III - BURGOS DEL CARMEN SANTA MONICA SURIGAO DEL NORTE; INTENSITY II - SURIGAO CITY; SOCORRO SURIGAO DEL NORTE
2014	15			5.1	INTENSITY III - BURGOS SURIGAO DEL NORTE; INTENSITY II - CARMEN SURIGAO DEL NORTE
2014	20	4.7	5.7	5.1	INTENSITY III - BURGOS SURIGAO DEL NORTE; INTENSITY II - CARMEN SURIGAO DEL NORTED
2014	32	4.8	5.8	5.2	INTENSITY III - LIBJO DINAGAT PROVINCE; INTENSITY II - DAPA SIARGAO SURIGAO DEL NORTE; INTENSITY I - SURIGAO CITY
2014	10	4.9	5.9	5.4	INTENSITY V - PLACER AND SAN FRANCISCO SURIGAO DEL NORTE; INTENSITY IV - SURIGAO CITY; MALIMONO GIGAQUIT AND MAINIT SURIGAO DEL NORTE; SAN RICARDO SOUTHERN LEYTE; INTENSITY III - BUTUAN CITY; CLAVER SURIGAO DEL NORTE; SAN FRANCISCO SOUTHERN LEYTE; INTENSITY II-HINUNANGAN SOUTHERN LEYTE; MANAY DAVAO ORIENTAL; INTENSITY I - KIDAPAWAN CITY
2014	1	4.7	5.7	5.1	INTENSITY III- TANDAG SURIGAO DEL SUR; INTENSITY II- SAN MIGUEL SURIGAO DEL SUR
2014	1			5.6	INTENSITY IV - SURIGAO CITY & GENERAL LUNA SURIGAO DEL NORTE; INTENSITY III - TANDAG SURIGAO DEL SUR; INTENSITY II - SAN JOSE DINAGAT ISLAND SURIGAO DEL NORTE; BAYABAS & TAGO SURIGAO DEL SUR
2014	1			5.5	INTENSITY II - SURIGAO CITY
2014	80	4.6	5.6	5	INTENSITY I - SURIGAO CITY
2014	20	4.6	5.6	5	INTENSITY V - DEL CARMEN SOCORRO GIGAGUIT SURIGAO DEL NORTE; INTENSITY IV - SURIGAO CITY; MABUA SURIGAO CITY; INTENSITY III - LORETO DINAGAT ISLAND; BURGOS SURIGAO DEL NORTE; BUTUAN CITY; SAN RICARDO PINTUYAN SOUTHERN LEYTE; INTENSITY II - MAINIT SURIGAO DEL NORTE
2014	14	4.7	5.7	5	INTENSITY V- TALACOGON AGUSAN DEL SUR; INTENSITY IV - LA PAZ AGUSAN DEL SUR; INTENSITY III - BAYUGAN CITY; SAN FRANCISCO AGUSAN DEL SUR; INTENSITY II - BUTUAN CITY
2014	25	4.7	5.7	5	INTENSITY III - SURIAGO CITY; SOCORRO AND GENERAL LUNA SURIGAO DEL NORTE; INTENSITY II - DAPA SURIGAO DEL NORTE AND BUTUAN CITY; INTENSITY I - TACLOBAN CITY
2014	7	4.9	5.9	5.5	INTENSITY I - SURIGAO CITY
2015	22	4.8	5.8	5.2	INTENSITY III - CARRASCAL SURIGAO DEL SUR; INTENSITY II - SURIGAO CITY; BUTUAN CITY; GENERAL LUNA SIARGAO; INTENSITY I - CABALIAN SOUTHERN LEYTE; TACLOBAN CITY
2016	10	4.8	5.8	5.2	INTENSITY III - BURGOS SURIGAO DEL NORTE; INTENSITY II SURIGAO CITY SURIGAO DEL NORTE; INTENSITY I - MAINIT SURIGAO DEL NORTE
2016	8	5	5.9	5.5	INTENSITY IV - CARRASCAL SURIGAO DEL SUR; GENERAL LUNA SURIGAO DEL NORTE; INTENSITY III - BUTUAN CITY; TANDAG CITY; HINUNANGAN SOUTHERN LEYTE; INTENSITY II - BISLIG CITY; GINGOOG CITY; PALO LEYTE; INTENSITY I - CAGAYAN DE ORO CITY
2016	96	4.6	5.6	5	INTENSITY IV - CATEEL DAVAO ORIENTAL; BISLIG HINATUAN & BAROBO SURIGAO DEL SUR BUNAWAN LA PAZ & TALACOGON AGUSAN DEL SUR; INTENSITY III - LINGIG AND LIANGA SURIGAO DEL SUR; TANDAG CITY AND TENTO AGUSAN DEL SUR; INTENSITY II - CAGAYAN DE ORO CITY; VALENCIA BUKIDNON; MARIHATAG SURIGAO DEL SUR SANTA JOSEFA AGUSAN DEL SUR
2016	12	4.9	5.9	5.3	INTENSITY VI- SISON SURIGAO DEL NORTE; INTENSITY V- PLACER MALIMONO SURIGAO DEL NORTE & SURIGAO CITY; INTENSITY IV- BACUAG GIGAQUIT MAINIT CLAVER SURIGAO DEL NORTE SAN JOSE DINAGAT ISLAND PINTUYAN & SAN RICARDO SOUTHERN LEYTE; INTENSITY III- SOCORRO SURIGAO DEL NORTE SAN FRANCISCO & LIMASAWA SOUTHERN LEYTE; INTENSITY II- DAPA SURIGAO DEL NORTE & BUTUAN CITY; INTENSITY I- GINGOOG CITY MISAMIS ORIENTAL & CEBU CITY
2016	6	5.3	6.3	6	INTENSITY VI - TALACOGON ROSARIO LORETO & LA PAZ AGUSAN DEL SUR; INTENSITY V - PROSPERIDAD AGUSAN DEL SUR; BUNAWAN AGUSAN DEL SUR; INTENSITY IV - BUTUAN CITY; HINATUAN SURIGAO DEL SUR; TAGUM CITY;

Year	Depth (km)	Ml	Mb	Ms	Intensity Reports
					INTENSITY III - GINGOOG MEDINA BALINGASAG SALAY JASAAN & BALINGOAN MISAMIS ORIENTAL; BISLI CITY; DAVAO CITY; TALAINGOD SAN ISIDRO KAPALONG & SAMAL ISLAND DAVAO DEL NORTE; INTENSITY II - CAGAYAN DE ORO CITY; INTENSITY I - KIDAPAWAN CITY
2016	34	4.9	5.8	5.3	INTENSITY V - NASIPIT & CARMEN AGUSAN DEL NORTE; BUTUAN CITY; INTENSITY IV -MAINIT & PLACER SURIGAO DEL NORTE; CABADBARAN CITY LAS NIEVES REMEDIOS ROMUALDEZ & MAGALLANES AGUSAN DEL NORTE; INTENSITY III - SURIGAO CITY; GINGOOG CITY MISAMIS ORIENTAL; MAMBAJAO CAMIGUIN; SISON BACUAG & TAGANAAN SURIGAO DEL NORTE; INTENSITY II - CAGAYAN DE ORO CITY; CEBU CITY
2016	24	4.7	5.7	5	INTENSITY IV- BURGOS SURIGAO DEL NORTE; INTENSITY III- SURIGAO CITY; HINUNANGAN SOUTHERN LEYTE
2016	41	4.9	5.9	5.4	INTENSITY V- SAN BENITO SURIGAO DEL NORTE; INTENSITY IV- SANTA MONICA BURGOS DAPA SOCORRO PILAR TAGANAAN GEN. LUNA ALEGRIA BACUAG & SISON SURIGAO DEL NORTE; DINAGAT & LORETO DINAGAT ISLANDS; SURIGAO CITY; MAYORGA LEYTE; SAN JUAN PINTUYAN HINUNANGAN SOUTHERN LEYTE; INTENSITY III- CLAVER & TUBOD SURIGAO DEL NORTE CAGAYAN DE ORO CITY; BUTUAN CITY;PALO LEYTE; INTENSITY I - GINGOOG MISAMIS ORIENTAL; MAMBAJAO CAMIGUIN
2016	17	4.9	5.8	5.3	INTENSITY V - SAN ISIDRO SURIGAO DEL NORTE; INTENSITY IV- GENERAL LUNA SURIGAO DEL NORTE; INTENSITY III - DAPA SURIGAO DEL NORTE; INTENSITY II - SOCORRO SURIGAO DEL NORTE; INTENSITY I - SURIGAO CITY
2017	9	5.8	6.7	6.7	INTENSITY VII - SURIGAO CITY; INTENSITY VI- MALIMONO & SAN FRANCISO SURIGAO DEL NORTE; PINTUYAN SOUTHERN LEYTE;; INTENSITY V- MAINIT & PLACER SURIGAO DEL NORTE; LIBJO & SAN JOSE DINAGAT ISLAND; MANDAUE CITY SAN RICARDO LIMASAWA & SAN FRANCISCO SOUTHERN LEYTE;; INTENSITY IV- HINUNANGAN & SAN JUAN SOUTHERN LEYTE;ABUYOG LEYTE;MAYORGA LEYTE BUTUAN CITY; CABADBARAN AGUSAN DEL NORTE; INTENSITY III- MAMBAJAO CAMIGUIN;ORMOC CITY; PALO PASTRANA TOLOSA & TACLOBAN LEYTE; CATBALOGAN CITYW.SAMAR ; BISLIG CITY GINGOOG CITY MISAMIS ORIENTAL; DAPA SURIGAO DEL NORTE; ILIGAN CITY; CAGAYAN DE ORO CITY; INTENSITY II- CEBU CITY; TALOCOGON AGUSAN DEL SUR; DUMAGUETE CITY; TAGBILARAN CITY BOHOL; CAPOOCAN LEYTE; EL SALVADOR MISAMIS ORIENTAL; OROQUIETA CITY AND PLARIDEL MISAMIS OCCIDENTAL
2017	23	4.7	5.6	5	INTENSITY V - SURIGAO CITY; INTENSITY IV - MALIMONO SURIGAO DEL NORTE; SAN JOSE & DINAGAT ISLAND; INTENSITY III - BUTUAN CITY; INTENSITY II - SAN RICARDO & SAN FRANCISCO SOUTHERN LEYTE; GINGOOG CITY
2017	10	5.3	6.2	5.9	INTENSITY VI - SURIGAO CITY; INTENSITY V - BASILISA CAGDIANAO AND SAN JOSE DINAGAT ISLANDS; MALIMONO SURIGAO DEL NORTE; INTENSITY IV - BUTUAN CITY; JABONGA AGUSAN DEL NORTE; LIBJO DINAGAT ISLANDS; ALEGRIA AND MAINIT SURIGAO DEL NORTE; LIMASAWA AND SAN RICARDO SOUTHERN LEYTE; ; INTENSITY III - GINGOOG CITY; REMEDIOS T. ROMUALDEZ AGUSAN DEL NORTE; SAN FRANCISCO AND SAN JUAN SOUTHERN LEYTE; CLAVER SURIGAO DEL NORTE; ; INTENSITY II - GENERAL LUNA SURIGAO DEL NORTE; ORMOC CITY; CAGAYAN DE ORO CITY
2017	21	4.8	5.8	5.2	INTENSITY IV - TANDAG SAN MIGUEL BAYABAS AND CAGWAIT SURIGAO DEL SUR;; TALACOGON AGUSAN DEL SUR; INTENSITY III - SURIGAO CITY SOCORRO GENERAL LUNA PILAR MAINIT DEL CARMEN AND BURGOS SURIGAO DEL ; NORTE; CABADBARAN CITY REMEDIOS T. ROMUALDEZ MAGALLANES TUBAY SANTIAGO JABONGA AND ; KITCHARAO AGUSAN DEL NORTE; INTENSITY II - BUTUAN CITY; HINATUAN SURIGAO DEL SUR; SISON MALIMONO AND SAN FRANCISCO SURIGAO DEL ; NORTE; BISLIG CITY; LORETO DINAGAT ISLAND
2017	17	4.8	5.8	5.2	INTENSITY IV - BURGOS SURIGAO DEL NORTE; INTENSITY III - TACLOBAN CITY; PALO LEYTE; SURIGAO CITY; INTENSITY II - LIBJO SAN JOSE CAGDIANAO DINAGAT ISLANDS
2017	10	4.7	5.7	5.1	INTENSITY IV - BURGOS PILAR AND DAPA SURIGAO DEL NORTE; INTENSITY III- DINAGAT AND SAN JOSE DINAGAT ISLANDS; INTENSITY II - SURIGAO CITY AND SOCORRO SURIGAO DEL NORTE

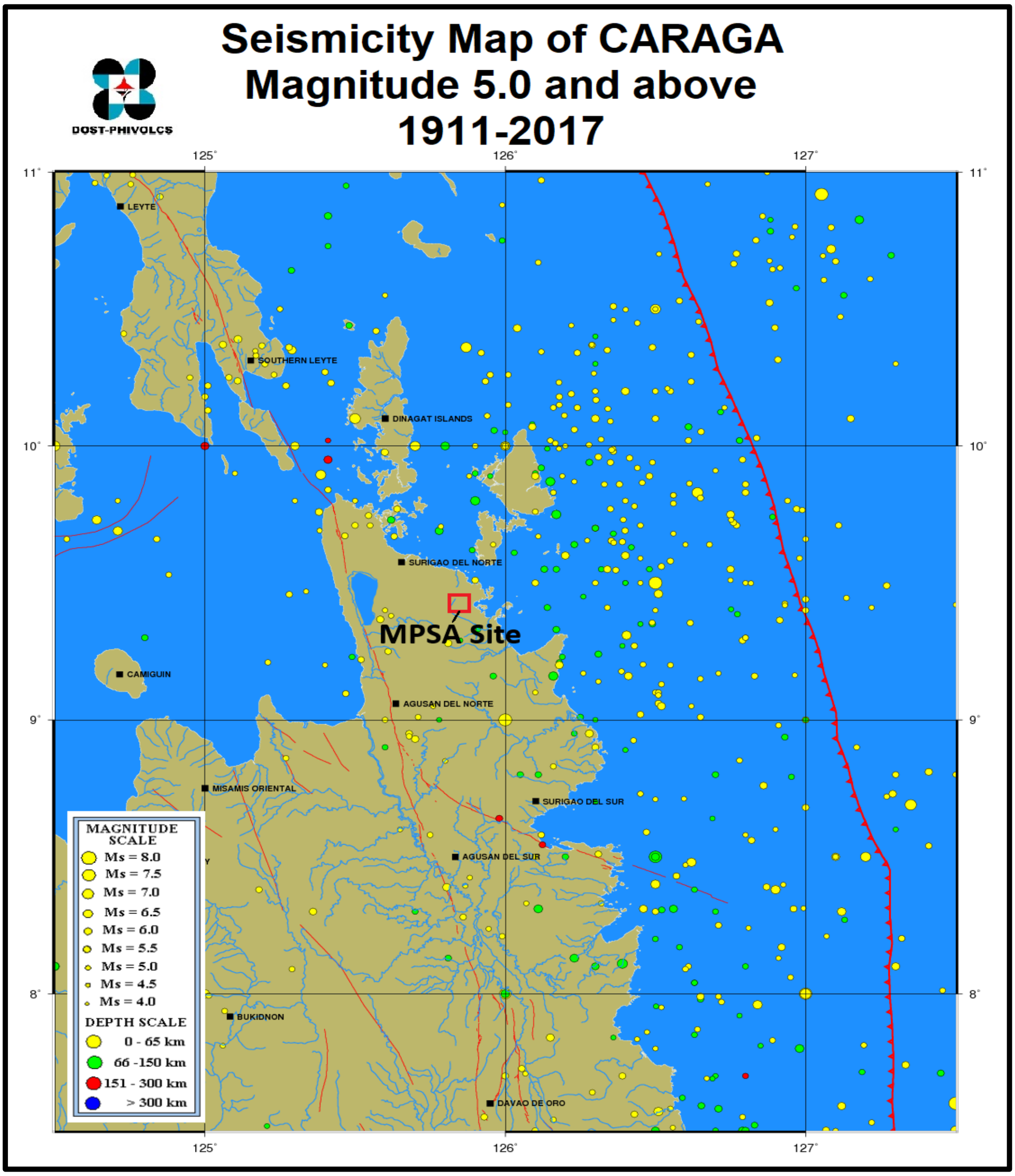
Note: RF - Rossi-Forel Intensity Scale
PEIS - PHIVOLCS Earthquake Intensity Scale

Source: PHIVOLCS-SOEPD, 2017



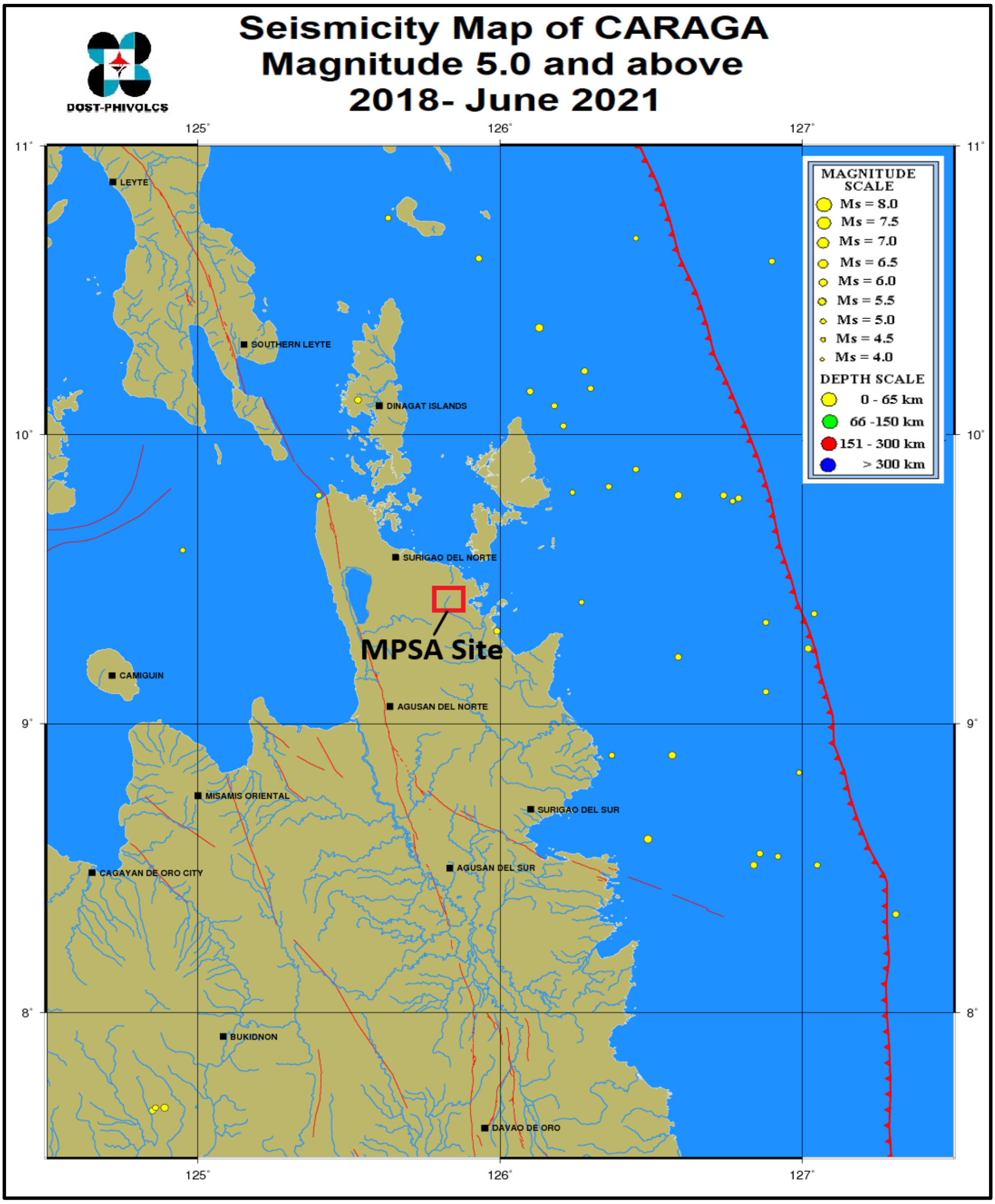
Source: PHIVOLCS-GGRDD, 2018

Figure 2.1.13: Active Faults and Trenches Map of MPSA and Vicinity



Source: PHIVOLCS-SOEPD, 2021

Figure 2.1.14: Seismicity Map of CARAGA and Vicinity; 1911-March 2017 Magnitude 5.0 and Above



Source: PHIVOLCS-SOEPD, 2021

Figure 2.1.15: Seismicity Map of CARAGA and Vicinity; 2018-March 2021 Magnitude 5.0 and Above

2.1.2.3.2 Ground Acceleration

The peak acceleration is the largest increase in velocity recorded by a particular station during an earthquake. It is the measure of how hard the earth shakes at a given geographic point. Moreover, areas with expected PGA values higher than 0.4 are classified as very high damage risk zone as per National Structural Code of the Philippines (NSCP), 2015.

For the Philippine Fault segments in Eastern Mindanao: Surigao and Esperanza, a probable M7.0 was assigned, M6.7 for the Lianga Fault, M6.9 for the Central Mindanao Fault, and M7.6 for the Philippine Trench, correspondingly. A method of calculating aseismic design value is the deterministic approach using the attenuation relationship equation developed by Fukushima and Tanaka in 1990. A design earthquake is assumed to occur at a point along the causative fault that is nearest to the site. Since this formula calculates peak acceleration at the surface, correction is required when this formula is applied to estimating ground motion on bedrock. Correction factors are applied to the mean peak acceleration depending on the type of foundation material: rock, 0.6; hard soil, 0.87; medium soil, 1.07; and soft soil, 1.39. The results of the computation of peak ground acceleration is summarized in **Table 2.1.4**.

The Deterministic Method developed by Fukushima and Tanaka (1990) was used to assess the worst-case scenario of ground shaking:

Log10A = 0.41M – log10 (R + 0.32 x 10 0.41M) – 0.0034R + 1.30

Where: A = mean peak acceleration (cm/sec2)
R = shortest distance between site and fault (km)
M = surface-wave magnitude

Table 2.1.4: Peak Ground Acceleration Values based on Fukushima and Tanaka (1990)

Seismic Source			g	Calculated PGA (g) Values				A (cm/s²)
Name of Structure	Magnitude (M)	Distance (km), R		g Rock	g Hard Soil	g Medium Soil	g Soft Soil	
PF: Surigao Segment	7.0	34	0.200	0.120	0.174	0.214	0.278	196.3628
PF: Esperanza Segment	7.0	63	0.106	0.064	0.092	0.114	0.148	104.1528
Lianga Fault	6.7	88	0.054	0.032	0.047	0.058	0.075	52.8473
Philippine Trench	7.6	122	0.062	0.037	0.054	0.067	0.087	61.2199
Central Mindanao Fault	6.9	141	0.028	0.017	0.024	0.030	0.039	27.4485

For a M7.0 earthquake along the Philippine Fault Zone, which is approximately, 34 and 63 km away from the MPSA site, calculations resulted to a peak ground acceleration of 196.3628 cm/^{2} and 104.1528 cm/s^2. On the other hand, for a magnitude 6.7 earthquake, whose trace to the MPSA site is approximately 88 km away, resulted to a peak ground acceleration of 52.8473 cm/s^2, the aseismic value is 0.054g. The seismic source, Philippine Trench, which can generate a magnitude 7.6 earthquake, with a distance of about 122 km from the project site, resulted to a peak ground acceleration of 61.2199 cm/s^2 and an aseismic value of 0.062 g. Likewise, the Central Mindanao Fault which is 141 km away has resulted to an aseismic value of 0.028 g.

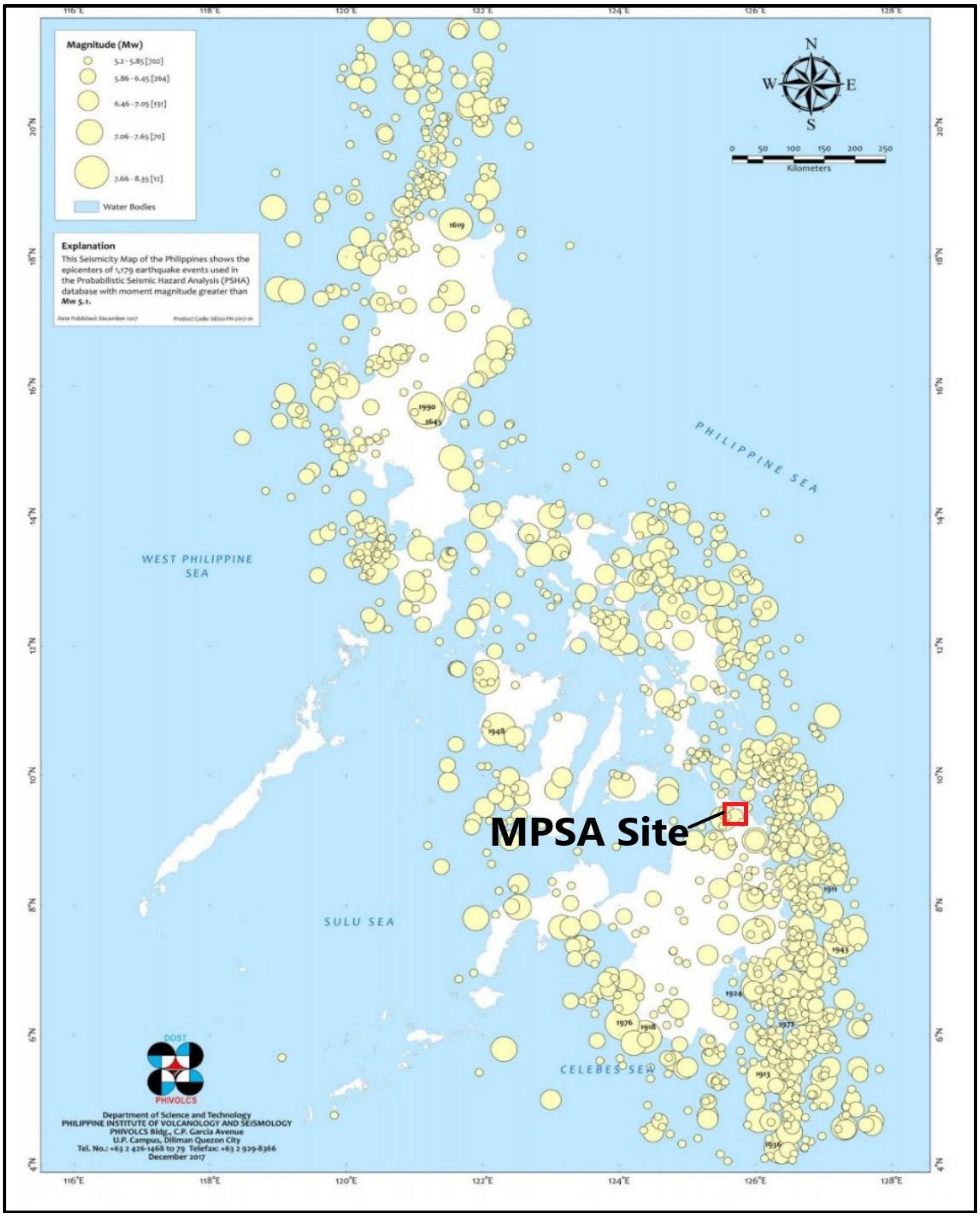
Based on results derived from the computation (**Table 2.1.4**), average peak ground acceleration values computed for a M7.0 MCE generated by the Surigao Segment of the Philippine Fault Zone can potentially generate the strongest shaking in the project area site ranging from 0.120 (rock) to 0.278 (soft soil) *g*. The pga values indicate that tectonic activity in the project site is very low to low.

Figure 2.1.16 presents some earthquake events in the Philippines used in the Probabilistic Seismic Hazards Analysis (PSHA)-Peak Ground Acceleration (PGA) of the Philippine Earthquake Model (PEM) of PHIVOLCS with moment magnitude greater than Mw 5.1.

Figure 2.1.17 shows the probabilistic peak ground acceleration at rock site model (Soil Class C, Vs30=760 m/s) with 10% probability of exceedance in 50 years and indicates the maximum site acceleration response from a most probable earthquake. The PGA ratio (PGA value in g/1g) approximates the seismic coefficient, Ca in the National Structural Code of the Philippines (NSCP) used in the seismic design of regular structures.

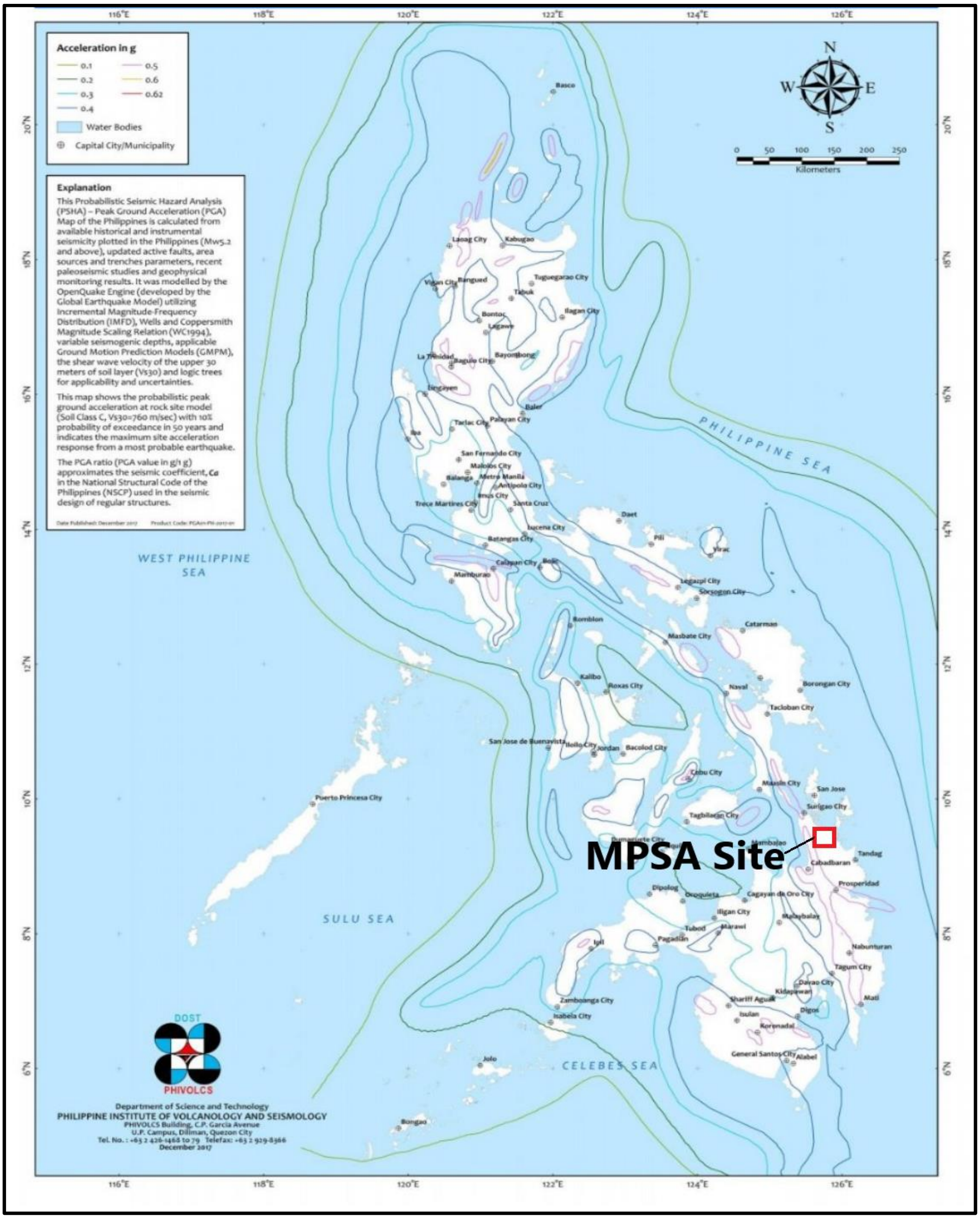
Figure 2.1.18 shows the probabilistic peak ground acceleration at soft rock or stiff soil site model (Soil Class D, Vs30=360 m/s) with 10% probability of exceedance in 50 years.

These PSHA-PGA maps of the Philippines is calculated from the available historical and instrumental seismicity plotted in the Philippines (Mw5.2 and above), updated active faults, area sources and trenches parameters, recent paleoseismic studies and geophysical monitoring results.



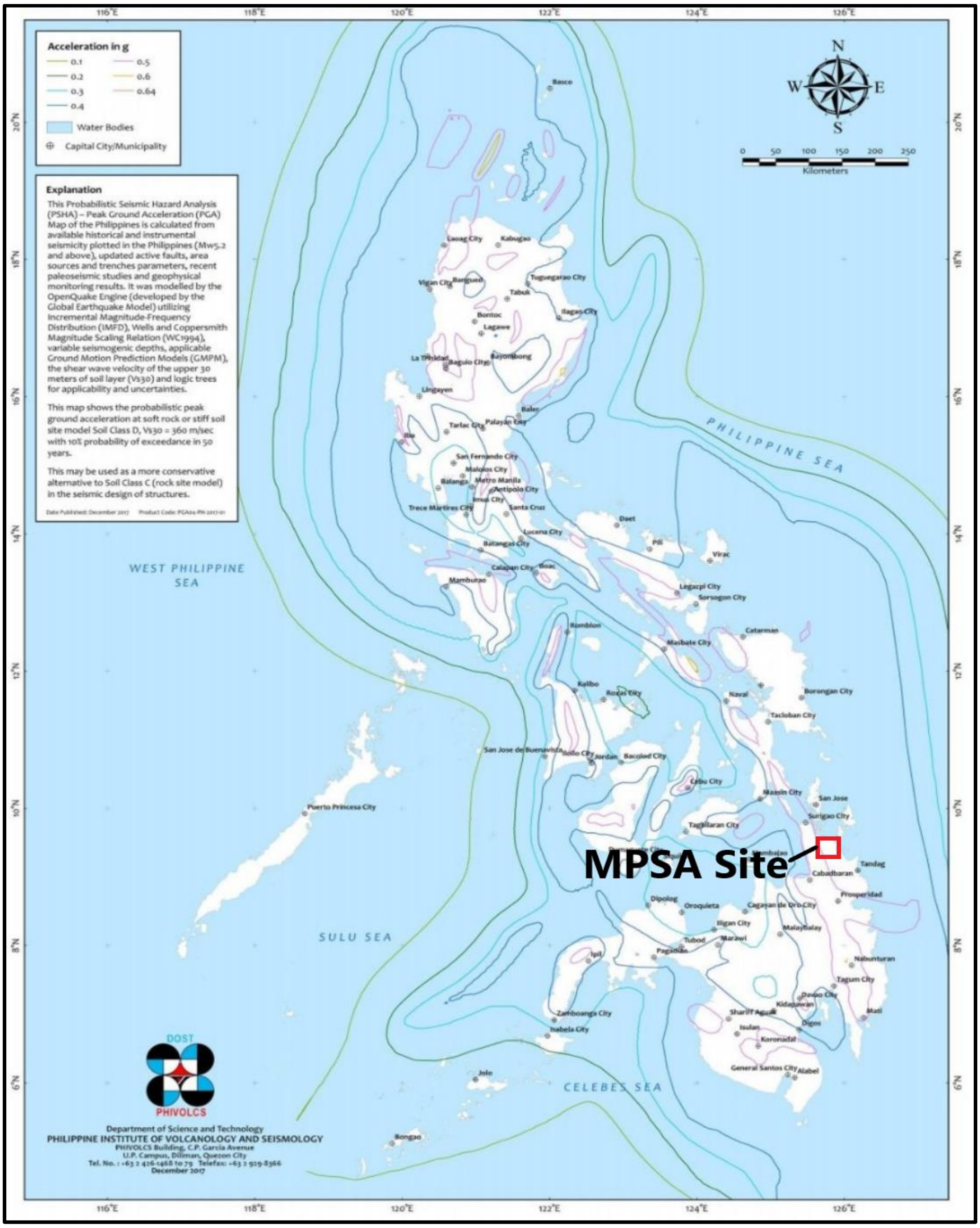
Source: Philippine Earthquake Model (PEM), PHIVOLCS 2017

Figure 2.1.16: Seismicity Map used in PSHA-PGA database with magnitudes > Mw5.1



Source: Philippine Earthquake Model (PEM), PHIVOLCS 2017

Figure 2.1.17: Probabilistic PGA at Rock Site Model of Project Site



Source: Philippine Earthquake Model (PEM), PHIVOLCS 2017

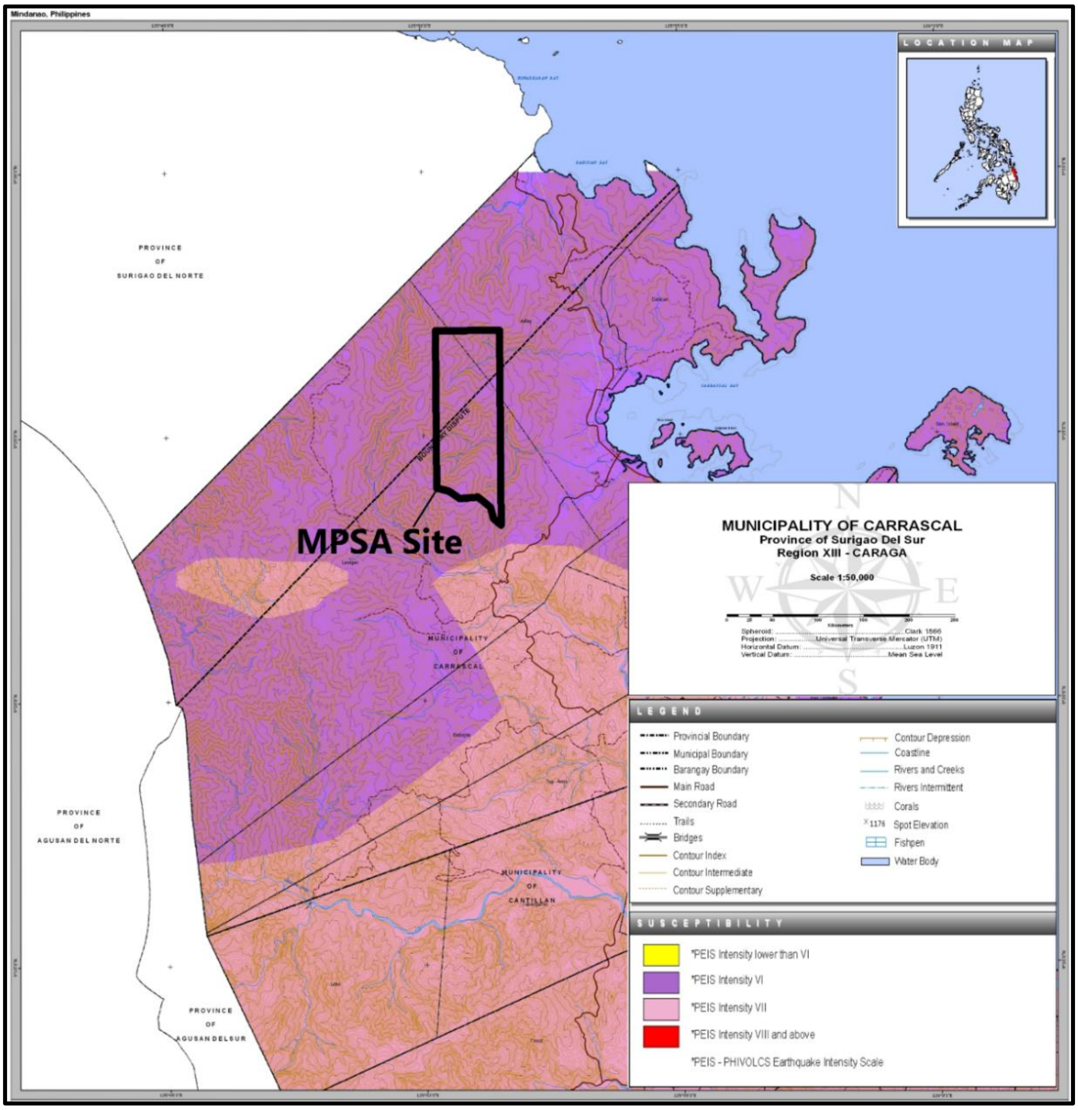
Figure 2.1.18: Probabilistic PGA at Soft Rock or Stiff Soil Site Model of Project Site

2.1.2.3.3 Ground Shaking

Ground shaking is caused by seismic waves and is the primary hazard associated with earthquakes. During large earthquake events, seismic waves can either radiate underground as body waves, or move aboveground as surface waves. Typically, the ground motion felt in earthquakes are body waves, which are described as the kind of shaking where furniture moves laterally and unstable objects fall to the ground. Even more destructive are surface waves, wherein ground moves in a wavelike manner, briefly changing the shape of the surfaces they pass through, resulting in extreme damages (Punongbayan and Torres, 1990).

The most serious direct effect of an earthquake in terms of buildings and structures is ground shaking (F.G. Bell, 2002). In this aspect, the ground conditions, such as the surface and bedrock geology, of the foundation of the buildings must be investigated. Previous studies have found out that earthquake intensities vary in areas, which have different geology. The intensity decreases in areas where harder rocks, such as granite and basalt, are prevalent. Conversely, the intensity increases in areas where loose and wet sediments are common.

Susceptible are the steep to very steep slopes in the midsection, northern, and western flank of the project site, while the low to moderate terrains, poses less risk to ground movements except for minor shaking that pose no direct hazard to well-structured pit benches. **Figure 2.1.19** shows project area and vicinity in relation to the maximum ground-shaking scenario of the fault systems in the region generated by PHIVOLCS. The project site falls under PEIS Intensity VI: Very Strong Ground Shaking wherein limited rock falls and rolling boulders may occur in hilly to mountainous areas and escarpments.



Source: PHIVOLCS, 2016

Figure 2.1.19: Ground Shaking Hazard Map of the Project Site and Vicinity

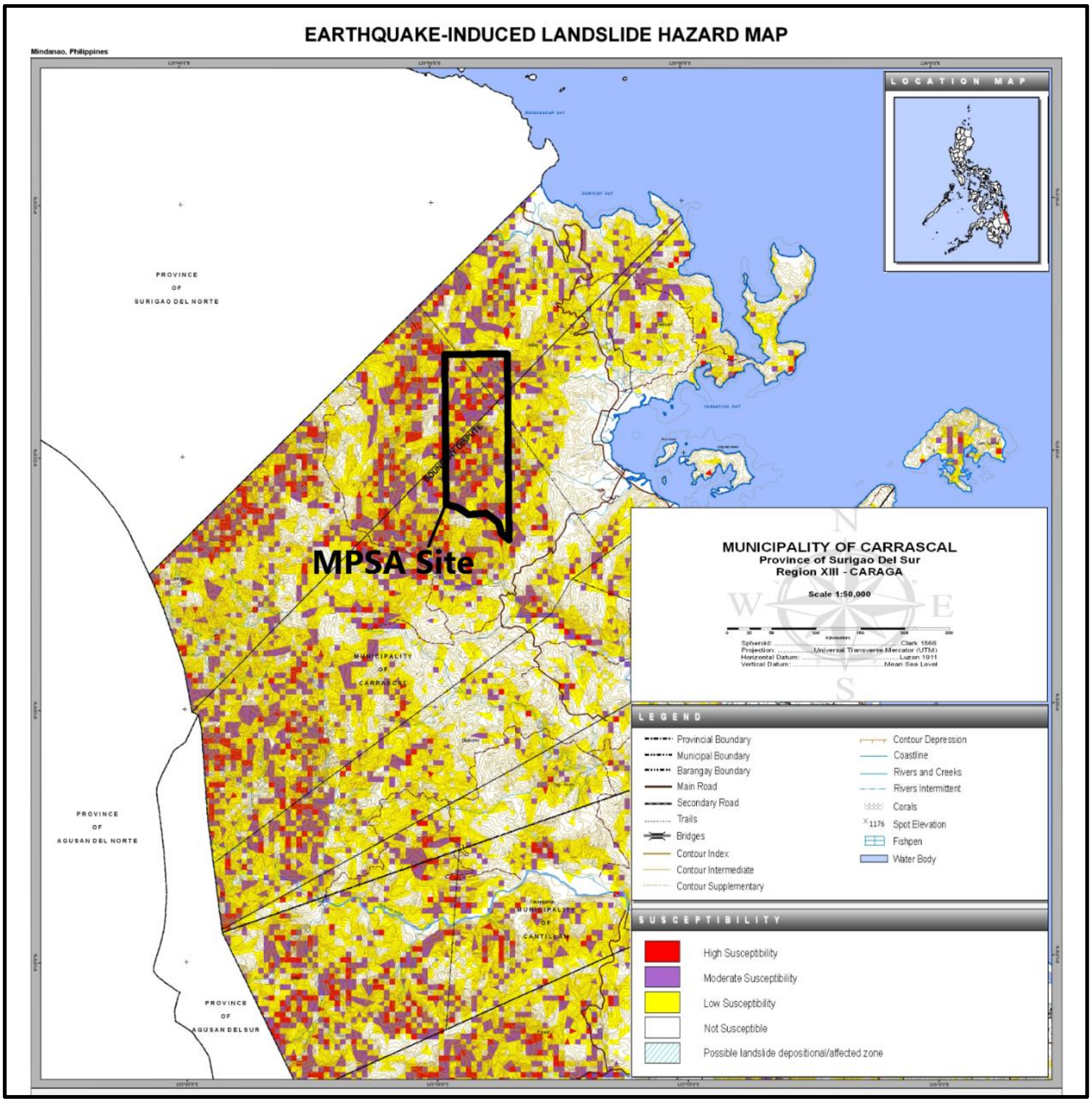
2.1.2.3.4 Ground Rupture

A ground rupture occurs along a fault that cuts through the surface. Depending on the type of fault, this rupture may have a vertical, horizontal, or oblique displacement that is likely to cause considerable damage to structures built on it. The amount of displacement and length of rupture depends on the earthquake magnitude, distance of site from the fault or fault zone, and ground conditions.

Thick laterite soil cover overlying sheared ultramafic units with conglomerate and spilitic basalts, blankets the project site. Although apparent ground rupturing and tension cracks caused by strong earthquakes in the past were not observed at the site and vicinity, any strong earthquake related to the segments of the Philippine Fault Surigao segment could cause breakage in the competence of the underlying bedrock.

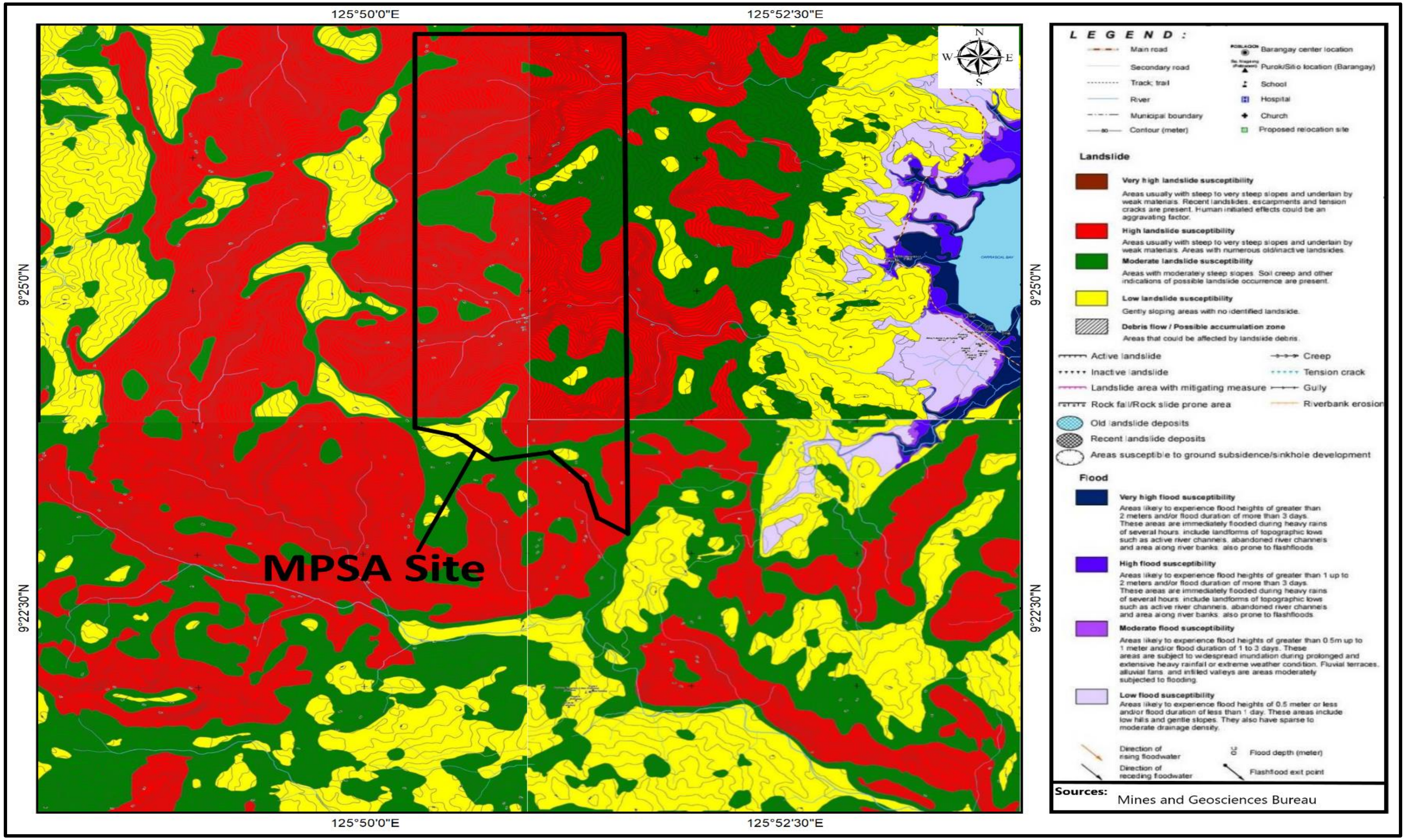
2.1.2.3.5 Landside

The peaks and highly elevated areas of the province site are prone to landslide brought about by either earthquakes or rainfall. Rainfall-induced landslide is caused by geologic, morphologic or physical events that are either caused by natural and human forces. Landslides that occurred in recent years have been associated with high rainfall intensities or prolonged rainfall, though slope steepness, soil properties, presence of fault lines, vegetation and among others may likewise contribute to the occurrence of landslides. In the case of the MPSA site, the critical zones identified as vulnerable to landslides is shown in the map obtained from PHIVOLCS (**Figure 2.1.20**) and Mines and Geoscience Bureau (**Figure 2.1.21**). It is noticeable that critical or hazardous areas are those found along mountain ranges with steep slopes or those at the mountain fringe. Occurrence of landslides may also exacerbate soil erosion, thus sedimentation of rivers and waterways downstream to the nearby tributaries.



Source: PHIVOLCS, 2016

Figure 2.1.20: Earthquake-Induced Landslide Hazard Map of the Project Site and Vicinity



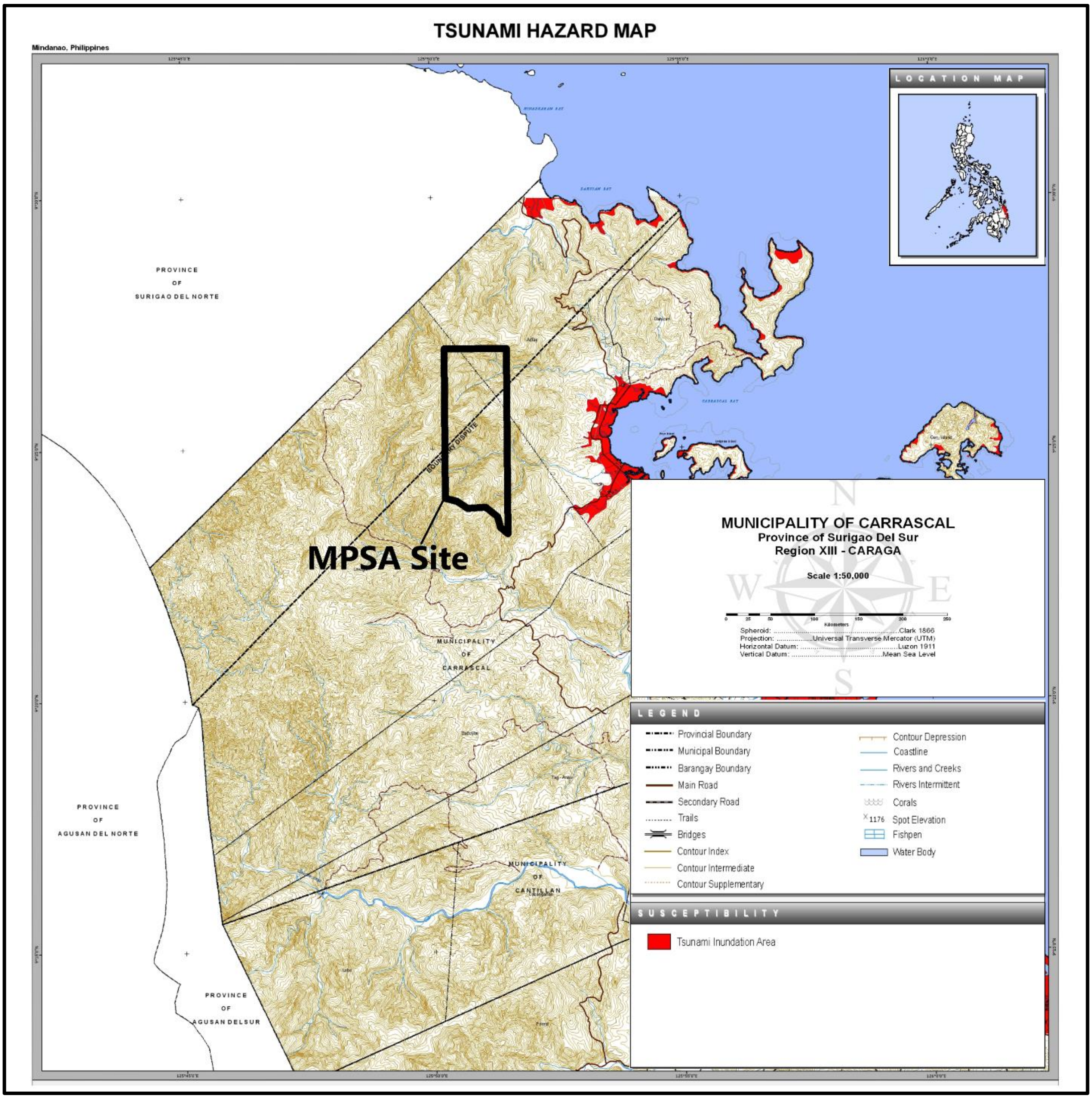
Source: Mines and Geosciences Bureau (MGB) Region XIII, 2017

Figure 2.1.21: Landslide and Flood Hazard Map of the Project Site

2.1.2.3.6 Tsunami

Tsunamis are a series of waves caused by the sudden displacement of a large volume of water by natural phenomenon such as earthquakes, volcanic eruptions, underwater landslides, or meteorite impacts. The waves can travel across open waters at vast distances and great speeds, building into shorter period but higher amplitude waves as they approach shallow bathymetries near the coast. Once on land, tsunamis can crash into buildings and structures, and incorporate the resulting debris to form destructive slurries that can travel several kilometers inland.

In Carrascal, the hazard can be generated by submarine earthquakes along the Philippine Trench, i.e., if the movement includes a vertical component that can displace a large parcel of seawater. Though the MPSA site is not susceptible to tsunami, the Carrascal Bay where the Causeway is located, may be exposed in a way, to such hazard particularly when an earthquake of Magnitude 8 will occur in the Philippine Trench (**Figure 2.1.22**). When an offshore fault moves laterally as in the case of the nearby Philippine Fault, the earthquake will not generate a tsunami because no parcel of water will be displaced in such process. Thus, the location of the causeway and the operational facilities is not really prone to huge tsunamis but may experience some swelling of coastal waters.



Source: PHIVOLCS, 2016

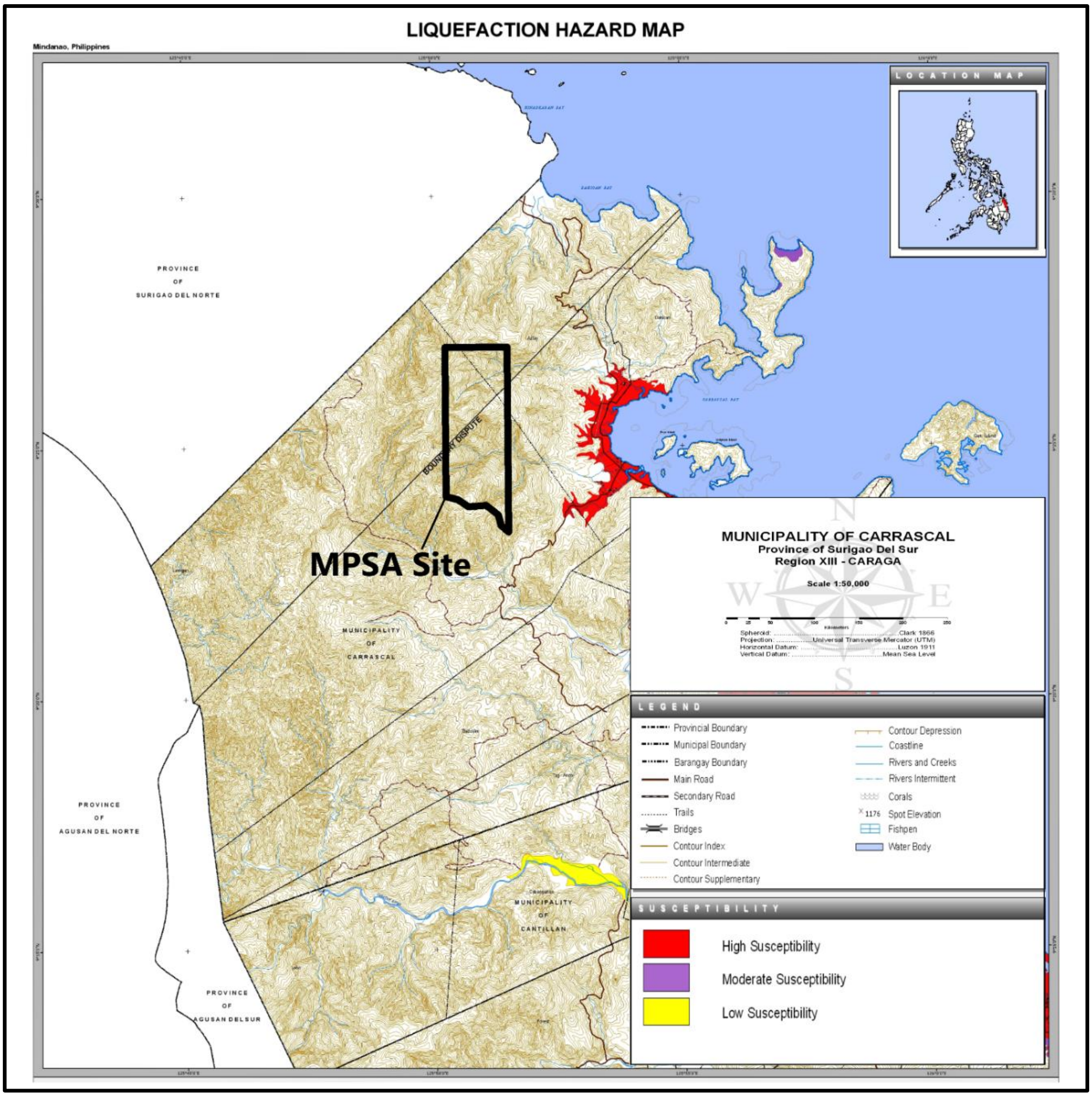
Figure 2.1.22: Tsunami Hazard Map of the Project Site and Vicinity

2.1.2.3.7 Liquefaction

Liquefaction occurs when certain types of water-saturated sands and muds substantially lose strength due to sudden ground-shaking, turning it into a slurry substance with liquid-like consistency (Kusky 2008). Any structure built on liquefied sediments can suddenly sink as if it were resting on thick fluid. The occurrence of liquefaction is influenced by the magnitude of the earthquake, ground acceleration, and distance from the epicenter, duration of the shaking, relative density of sediments, seismic history, and age of the deposit (Seed 1979; Torres et al. 2001).

Liquefaction hazard map of Surigao del Sur released by PHIVOLCS shows that only sparse areas within the province are actively prone to liquefaction. Note that these areas are found in known active tributaries where loosely consolidated alluvial materials are present. The project site, however, is generally not prone to liquefaction based on available data from the PHIVOLCS (**Figure**

2.1.23). The province-wide liquefaction hazard map of Surigao del Sur was based on geology, presence of active faults, historical accounts of liquefaction, geomorphology and hydrology of the province.



Source: PHIVOLCS, 2016

Figure 2.1.23: Liquefaction Hazard Map of the MPSA Site and Vicinity

2.1.2.3.8 Volcanic Hazards

The Philippines situated on the Pacific ring of fire, experiences seismic activities that occur on a daily basis. The oceanic Philippine plate and several smaller micro-plates are subducting along the Philippine Trench to the east, and Luzon, Sulu, and several other small trenches to the west thus volcanic activity is frequent.

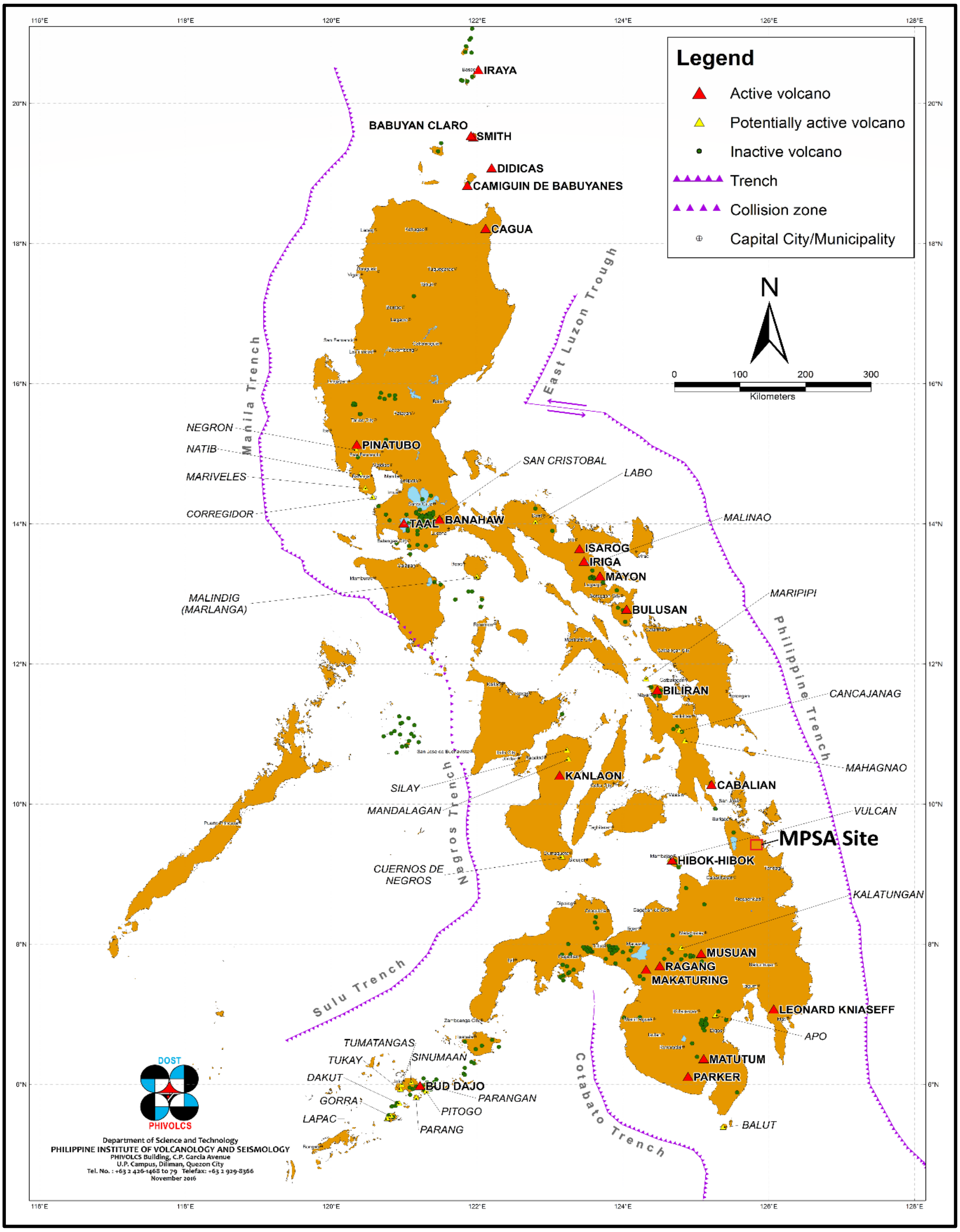
Mindanao has more than 50 individual volcanic centers and 20 of these were identified as quaternary in age. Only nine (9) volcanic centers are active, i.e., they erupted within the last 10,000 years as classified by the Philippine Institute of Volcanology and Seismology (PHIVOLCS). These are the Cabalian in Southern Leyte, Hibok-Hibok in Camiguin Island, Kalatungan in Bukidnon, Musuan in Bukidnon, Makaturing in Lanao del Norte, Ragang in Lanao del Sur, Matutum in South

Cotabato, Parker in South Cotabato-Sarangani, and Buddajo in Sulu. The most active among these volcanoes is Hibok-hibok. Hibok-hibok's last eruption was in 1953 but the most violent eruption was recorded in 1951 when 500 people died.

Within the MPSA area and its vicinity, there are no active volcanoes but there is one (1) active volcano at about >100 km northwest of the site (**Figure 2.1.24**), the Mt. Cabalian in Leyte and one (1) potentially active volcano at approximately 130 km east of the MPSA area, Mt. Vulcan in Catarman, Camiguin. A volcano is considered active if it has "erupted within the last 10,000 years or if it has a radiometric date of its deposit which is less than 10,000 years." (Solidum, 2015).

Cabalian is classified by the PHIVOLCS as active with solfataric activity. Radiocarbon dating on pyroclastic flow deposit from the volcano estimated that the last eruption was in 1820 (+/- 30 years).The stratovolcano has an elevation of 945 m (3,100ft) with a base diameter of 8.5km (5.3 mi). The predominant rock type is andesite. Besides solfataras, other thermal features present are hot springs located in the east and west flank of the volcano. Cabalian has 500 m diameter a lake that occupies the summit crater. The surface elevation of the lake is at 733 m. If this volcano erupts, the project site will experience ash fall.

Among the inactive volcano with no record of eruption, that is at least within the 50 km zone of the MPSA site is Mt. Paco in Surigao del Norte.



Source: PHIVOLCS, 2016

Figure 2.1.24: Active and Potentially Active Volcanoes of the Philippines

2.1.2.3.9 Mass Movement

Four (4) types of mass movements may occur in the mining areas assuming that the development will be extensive for slope stabilization measures to be implemented prior to the wet season. These are debris or landslides, slump, creep and possibly mud or debris flow. The triggering mechanism for all the three is heavy rainfall although the third may continue after a rainfall event. However, for the movements to occur, the following factors must be present:

1. Slopes must be covered by loose materials
2. Gravity forces them to move downslopes
3. That force should be greater than the friction holding them together
4. Friction is reduced through external intervention especially water
5. Angle of repose is overcome.

Creep is a slow movement of mass normally made up of soil over a more rigid underlay. On the other hand, slump is a form of slide that allows a block of materials to move downslope in a rotational manner as differentiated from debris or landslides (**Figure 2.1.25**).

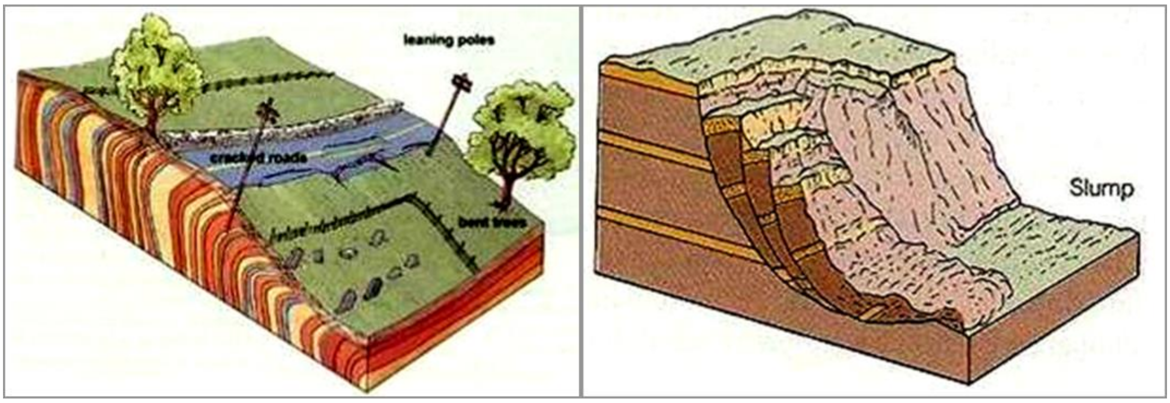


Figure 2.1.25: Creeping in a Low-Angled Slope (left) and Slumping in Step-Wise Fashion (right)

Debris slide refers to a movement in which a mass of earth materials moves downslope in a rapid fashion, graphically described in **Figure 2.1.26**.

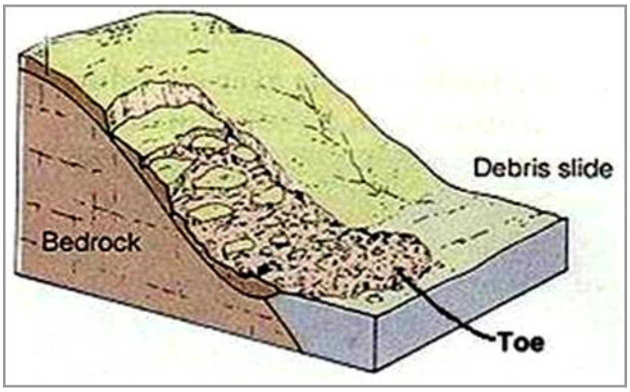


Figure 2.1.26: A Form of Slide that involves Rocks and Soil

Debris or mud flow is a rapid movement of earth materials with the aid of water. It will need a sustained extremely heavy rainfall to initiate such rapid movement. This is possible in the mining area.

At present however, there are no signs of any impending movements that could significantly impact the nearby communities. However, when the ground is massively disturbed, there is a chance that mass movements will be triggered.

2.1.2.3.10 Differential Settlement

Areas underlain by fine-grained soil and clay are subject to settlement and differential compaction. Those areas with low-density silts and clays associated with fluvial depositional environments are subject to this type of hazard. The extent of compaction may range from a few centimeters to several meters in depth. The potential for differential compaction is highest during large earthquakes.

Rapid geologic assessment of the projectsite shows thick laterite soil and clay are present on the site with underlying sheared peridotite units. These type of subsurface materials are less susceptible to differential compaction settlement hazards. However, proper compaction should be made if there would be earth filling at the site in case of rehabilitation management. Compaction of the ground would further reduce the risk from differential ground settling.

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

The project development will bring noticeable changes to the existing topography and surface landforms within the footprint of the MPSA claim.

Surface mining permanently changes the topography, terrain, and slope of the project area. However, the mountainous geomorphological unit remains the same. The establishment of new haul roads and rehabilitation of existing access routes and construction of benches in mining pits and siltation ponds will require excavation leading to the formation of steep slopes. Steepening of slopes usually promotes instabilities that often lead to slope failures when not provided with appropriate support.

Development of stockyard, pre-pile yard, and campsite will require leveling of slopes. Level to undulating slopes are prone to water ponding and often affected by flooding. The creation of siltation ponds and drainage canals will introduce depressions in the topography and change the natural flow paths.

Similarly, during operation, activities such as stripping, bench forming, and ore extraction activities will lower the elevation up to the designed mining limit.

In gentler slopes and flat surfaces, lateral spread may occur because of ground vibration with an accompanying semi-liquefaction process. The ground materials tend to spread laterally in all directions as it yields to the weight of the overlying strata or lithologic units.

The slopes that will be steepened during the construction of roads, waste dumps, and siltation ponds must be provided with slope stability measures to prevent or minimize slope failure. The design of the pit slope must be supported by a slope stability study to determine if it is stable throughout the active mining period.

During rehabilitation, the topography of the mined-out areas must be restored to a stable slope angle close to its natural form. As mentioned in the previous reports, the target slope design for mined-out areas is 40°. This must be supported by a geotechnical report to ensure that it is stable for the long term.

Relatively flat areas such as in the waste dumps, pre-pile yard, stockpile yard, and campsite must have sufficient gradient that will direct runoff towards drainage lines to avoid water ponding. If possible, diversion canals will also be directed towards the original natural waterways.

2.1.2.5 Change in Subsurface Geology/Underground Condition

As observed during the field investigation, the southern and eastern section of the project site is relatively stable from mass movements. Only minor rill and gully erosion were noted due to the action of surface runoff.

Areas located at the northern and western boundaries where steep slopes dominate are most likely be affected by these earth processes if no appropriate mitigating measures be implemented. As documented, minor amount of mass wasting was identified within the property as compared to some areas specifically on the mid-section area. This manifests that the underlying lithologic units within the previously mentioned area are more competent than the later areas underlain by ultramafic rock units. Most instabilities noted to have affected the underlying bedrock are those located within very steep slopes and newly opened road cuts.

Progressive and systematic land stripping or excavation would minimize exposure of the soil or rock to the elements. Rock and soil piles using that will be subsequently used for slope rehabilitation or vegetation cultivation will be protected to preserve quality.

Benches with appropriate heights and slope angles will be maintained to prevent failure. When deemed necessary, the installation of slope stabilization fixtures such as shotcrete, geotextile, weep holes, gabions, etc. will be considered. Dewatering pumps and runoff canals and galleries will be installed to control water accumulation inside the pit.

All fills and fill slopes shall be designed to protect groundwater quality, to prevent surface water ponding, to facilitate revegetation, to convey runoff in a non-erosive manner, and to account for long term settlement.

Backfilling, recontouring, and revegetation activities shall be performed in clearly defined phases to the engineering and geologic standards required for the end use of the site as stipulated in the approved Final Mine/ Rehabilitation and Decommissioning Plan (FMRDP).

2.1.2.6 Inducement of Subsidence, Liquefaction, Landslide, Mud/Debris Flow, etc.

The project site had been identified as belonging to a high danger zone probably because it is part of the Eastern Mindanao mountain range which exhibits rugged to steep slopes. However, actual condition of the MPSA does not conform to the landslide hazards map except perhaps on localized and isolated sections where mass movements were observed on steep slopes.

Excavations for the pit may uncover structural weaknesses within buried rock units and may promote the formation of extension fractures that could further weaken the rock. Pit excavations and rock/soil piling increases slope gradients which also heightens susceptibility to landslides.

Discharges from the siltation pond spillway could trigger flooding in downstream areas. Loose materials comprising the overburden material are susceptible to earthquake-induced slope failure and liquefaction.

To mitigate the potential effects of the geologic nature to the project and vice-versa, the following recommendations done are to be considered:

Detailed slope stability in all affected project facilities will be assessed to confirm hazard ratings assigned to the project site from previous geotechnical work. Ground truthing will be conducted on the critical areas to verify the assumptions and interpretations made from earlier boreholes and geotechnical logs.

Site-specific slope and ground conditions will be given particular consideration in the final design of the facilities and infrastructures to reduce the inducement of slope failures.

No waste materials except the overburden which consist of top soil, very low grade laterite and waste rocks removed during stripping of overburden will be produced. Products of ground preparation and development will eventually be used for other purposes and/or in the rehabilitation of the area after the life of mine.

- Rockfill embankments will be constructed to support excavations where applicable, which can be extended up to 15 m in height if free-drained. Horizontal drains and weep pipes will be installed in non-free draining sections. Both designs will be complimented with a designed drainage to prevent erosion. Geotextiles will also be used when applicable. Retaining walls and gabions will be placed in susceptible areas to reduce or handle low-key landslides.

- Surface and groundwater will be diverted from the mining areas to prevent oversaturation, excess erosion and slope failure.
- When deemed necessary, the installation of slope stabilization fixtures such as shotcrete, geotextile, weep holes, gabions, etc. will be considered.
- The siltation ponds will be regularly monitored for structural integrity.
- Surface diversion drains will be installed to channel runoff water away from mining areas and into natural waterways located downstream.
- The siltation pond will be designed to stand against flood events. The siltation pond design will follow standard requirements.
- An Emergency Response Plan will be developed to handle unlikely occurrence of impoundment failure and downstream flooding.

2.1.3 Pedology

2.1.3.1 Soil Types

The Bureau of Soils and Water Management (BSWM) system of classifying soils at soil series level is adopted in this study. There are nine major groups of soil series in the Philippines based on the physiography, parent materials, mode of formation, and the kind of soil profile. The soils covering the MPSA site belong to Kabatohan and San Manuel Series.

Kabatohan Series

Kabatohan series occurs on gently sloping or undulating to very steep moderately dissected hills and ridges on andesitic, basaltic or dacitic rocks. They are shallow to moderately deep and classified as coarse loamy mixed. These soils have strong to medium acid soil reaction and inherent fertility is low to moderate. The main land use and vegetative cover are coconut and banana, grasses, and shrubs and patches of fruit trees and root crops.

Kabatohan Loam

Under the USDA soil classification scheme, Kabatohan Loam is equivalent to oxisol which is normally characterized by high amount of oxides and hydroxides of iron and aluminum and therefore have extremely low pH ranging from 3.0 to less than 4.5. Soil is strongly reddish in color and the subsurface structures can be recognized. The oxisols in the province are also considered marginal soils because of their low organic matter, low bases, and low water holding capacity. They are also moderately eroded because they are situated in moderately steep to very steep slopes. The oxisol in this area is strongly reddish in color that makes it prominent even in water bodies where they are alluvially transported and deposited

At the mine site, the oxisol can be considered as serpentine soil. This type of soil is derived from ultramafic rocks; serpentine in particular, that is formed by the hydration and metamorphic transformation of peridotite and related rocks. The soil derived from ultramafic bedrock give rise to unusual and sparse associations of edaphic plants that are tolerant of extreme soil conditions such as low calcium-magnesium ratio, lack of essential nutrients such as nitrogen, potassium, phosphorus, and high concentrations of the heavy metals that are more common in ultramafic rocks. These plants are commonly called serpentine endemics.

The oxisol will be removed during operation and shipped out if it contains nickel with high assay values. If not, it will be treated as overburden or mine waste and stockpiled in a proper place for future use during mine rehabilitation. Since this soil will extremely be distributed and loosened it can be susceptible to excessive erosion that can eventually develop into mass wasting. Siltation of stream channels, tidal flats and seabed is expected to follow suit. The extent of siltation will depend basically on the grain size of sediment particles and the finer they are the farther they will settle.

Profile of Kabatohan Loam is presented in **Table 2.1.5.** Although located in Carmen, Surigao del Sur, the profile is essentially the same for the Kabatohan Loam in Carrascal, Surigao del Sur or Claver, Surigao del Norte.

Table 2.1.5: Soil Profile of Kabatohan Loam

Horizon	Depth (cm)	Description
A	0 – 32	Dark brown (7.5 YR 3/2) moist, clay; weak fine and medium angular to sub angular blockystructure; sticky, plastic, firm; many fine and medium roots; abrupt wavy boundary; pH. 5.4
Bt1	32 – 63	Strong brown (7.5 YR 5/0) moist, clay; moderate fine and medium angular to sub angular blocky structure; very thick, very plastic, firm; many fine and few medium roots; many fine continuous clay cutans; diffuse irregular boundary; pH. 5.2
Bt2	63 – 104	Reddish yellow (5YR 6/8) moist, clay; common fine distinct clear strong brown (7.5YR 5/8) mottles; moderate fine and medium angular to sub-angular; blocky; sticky, plastic, firm; few fine and few medium roots; few fine tubular pores; many fine clay cutans; diffuse irregular boundary; pH 5.2
Bt3	104 – 131	Yellowish red (5YR 5/8) moist; clay; moderate fine and medium angular to sub angular blocky; sticky, plastic, firm; few fine roots; few fine tubular pores; many fine clay cutans; diffuse irregular boundary; pH 5.2
BC	131 – 160	Reddish yellow (7.5 YR 7/8) moist, clay; moderate fine and medium angular to sub angular blocky; sticky, plastic, firm; many fine roots; few fine tubular pores; irregular boundary; pH 5.6
C	160 – 180	Brownish yellow (10YR 6/6) moist, clay; moderate medium and coarse angular to sub angular blocky; sticky, plastic, firm; many partially and highly weathered red (10YR 4/8) rock fragments; pH 5.4

San Manuel Series

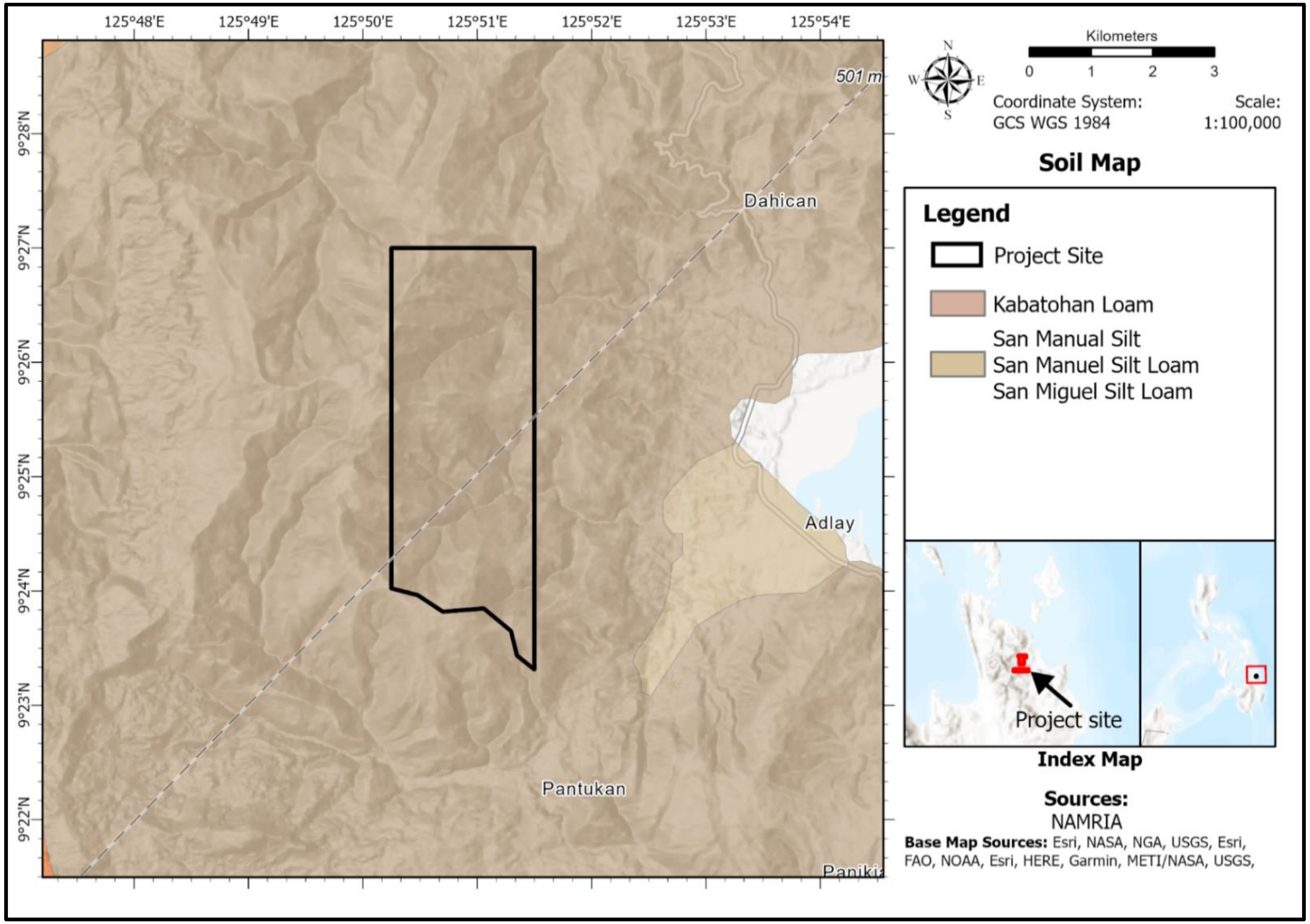
Generally, the San Manuel series is classified as fine loamy, mixed, isohyperthermic Fluventic Eutropepts. These are deep soils, well-drained on nearly to gently sloping river terraces or levees of minor alluvial plains. The soils are brown to dark brown, dark yellowish brown friable to firm clay loam, silty clay loam, silty clay, or silt loam. Inherent fertility is generally very high for paddy rice production with adequate organic matter but moderate for upland crops, where the organic matter can be considered deficient. The cation exchange capacity and the base saturation percentage are both adequate. The soil reaction is likewise adequate with pH ranging from 6.2 to 7.6. These soils are subjected to flooding by seasonal river overflow.

San Manuel Loam

San Manuel soil is classified as fine loamy, deep over sandy, non-acid, mixed, isohyperthermic *Typic Eutrudepts.* It has an A horizon that is brown silt to loam 10 – 25 cm thick. The cambic B horizon is brown, light clay loam. The C horizon below 100 – 150 cm thick is stratified, dark brown to yellowish brown, dominantly sandy with thin fine loamy strata and few grayish mottles. These soils are formed firmly stratified alluvium and can be found on medium or river terrace landscape position, or moderately high terraces adjacent to continental river channels and subject to seasonal flooding.

This is the largest single type in the province. The surface soil ranging in depth from 25 to 30 cm is light reddish brown, very friable, and finely granular clay. Spherical Tuffaceous concretions are present. The upper subsoil ranging in depth from 50-60 cm is dark reddish-brown, granular, and friable clay loam with fine spherical iron concretions. The lower subsoil to a depth of from 45 to 90 cm is a zone of highly weathered tuffaceous material. Few concretions are present. The substratum from 120 cm to an indefinite depth is coarse granular, dark reddish brown clay loam with numerous iron concretions.

Based on the soil survey and assessment conducted, the MPSA site belongs to the Kabatohan Loam and San Manuel (Silt) Loam. **Figure 2.1.27** shows the distribution of soil types in the project area and vicinity.



Source: BSWM-Soil Geomatics Division

Figure 2.1.27: Soil Map of Project Site and Vicinity

2.1.3.2 Soil Fertility/Quality

The existing soil characteristics were described by using data in the Soils of the Philippines by Carating, R.B., et al (2014), Soils Survey Report of Surigao del Sur by the BSWM, and the Lada Soil Series 2013.

Eight (8) soil and sediment samples were taken from four (4) stations on May 17-19, 2021 using the standard soil sampling method of the BSWM. Soil test pits have depth of up to 28 cm. Varying soil layers in both test pits were noted. Approximately 16 kilograms (kg) of sample were collected and kept in a thick plastic bags tied with a straw and labelled accordingly.

The description and the location map of the soil sampling stations are presented in **Table 2.1.6** and **Figure 2.1.28**, respectively. Photographs of soil and sediment sampling stations are presented in **Plate 2.1.6**.

Table 2.1.6: Description of Soil and Sediment Sampling Stations

Location	Sample ID	Northing	Easting	Remarks
South of MPSA Site	ND-S1A	9° 23' 41.12" N	125° 51' 19.3" E	Depth of Pit: 20cm
	ND-S1B			Depth of Pit: 28cm
Caayungan River	CAA-SED 1	9° 26' 31.23" N	125° 52' 33.86" E	Sediment Grab Sampling
	CAA-SED 2			
Marga River	MAR-SED 1	9° 24' 24.91" N	125° 52' 50.95" E	
	MAR-SED 2			
Pantukan River	PAN-SED 1	9° 22' 29.01" N	125° 51' 27.1" E	
	PAN-SED 2			

Plate 2.1.6: Photographs of Soil and Sediment Sampling Stations

The collected soil and sediment samples were submitted to Ostrea Mineral Laboratories, Inc. for analysis of the parameters pertaining to soil fertility and heavy metals, as presented in **Table 2.1.7**.

Table 2.1.7: Parameters Used in Determining the Quality of the Soil and Sediments Samples

Parameter	Test Method	Purpose
Parameters Pertaining to Soil Fertility		
Total Nitrogen (N)	Kjeldahl	Used to determine the total amount of nitrogen in the sample.
Total Phosphorous (P)	Titrimetric	Used to determine the total amount of phosphate in the sample.
Total Potassium (K)	Direct Air-Acetylene Flame	This parameter is a determinant of soil fertility and capability to deliver nutrients to plants.
Total Organic Matter (OM)	Walkley-Black (Colorimetric)	This parameter is a determinant of soil fertility.
Moisture Content	ASTM D 2216-10	This parameter is a determinant of soil fertility.
Iron (Fe), Manganese (Mn) Copper (Cu), Zinc (Zn)	Flame AAS/ Colorimetric/ Calculation	This parameter is a determinant of soil fertility.
Heavy Metals		
Metals: Arsenic (As), Cadmium (Cd) Chromium Hexavalent (Cr+6) Lead (Pb), Mercury (Hg) Copper (Cu)	Flame AAS/ Colorimetric/ Calculation	Data will be used as baseline environment values and utilized during monitoring periods to check for metal concentration changes in the environment.

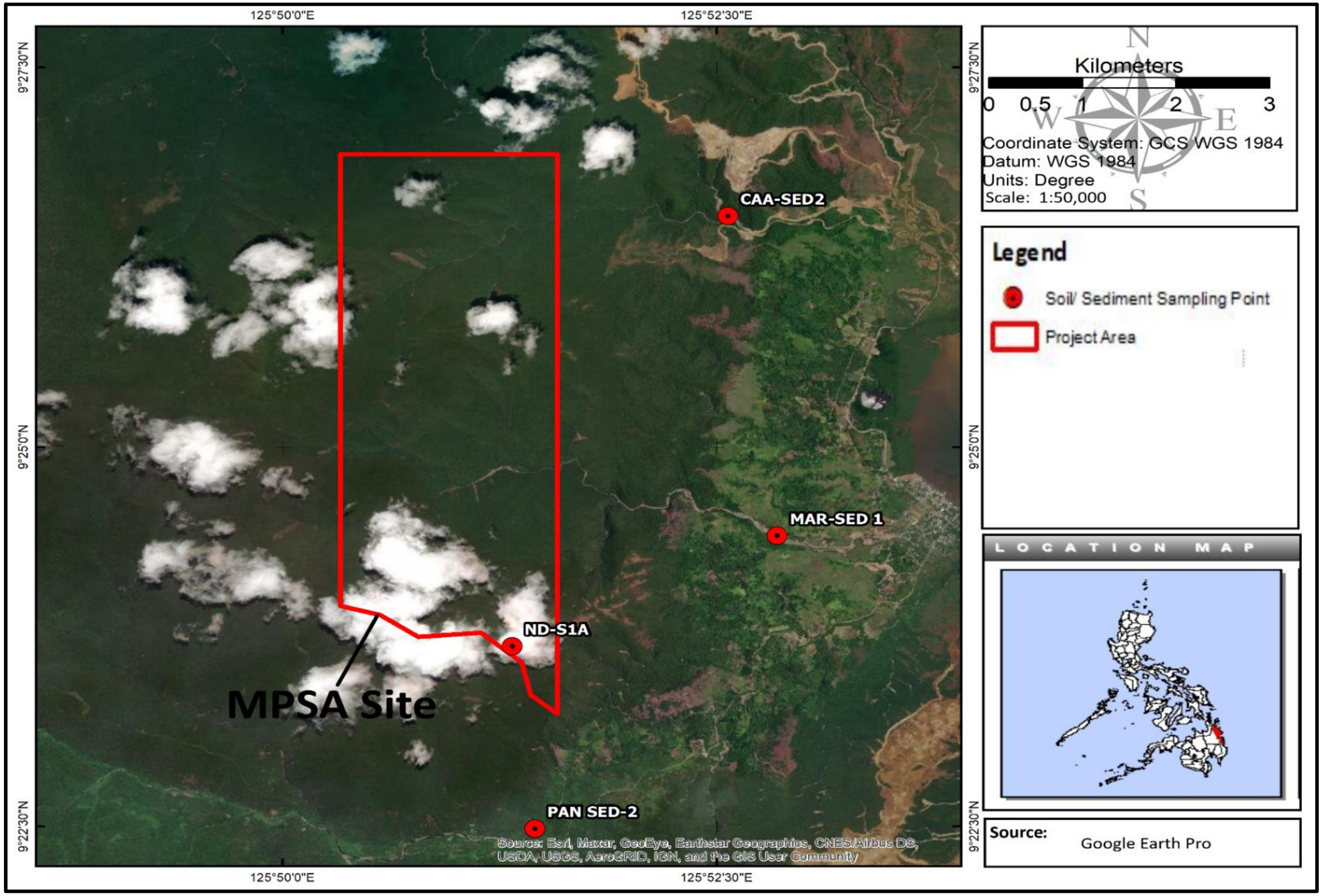


Figure 2.1.28: Location Map of Soil and Sediment Sampling Stations

2.1.3.2.1 Soil Fertility

The basis in assessing the inherent fertility of the soils present in the laboratory analysis involves factors that include soil pH, available phosphorous (P), exchangeable potassium (K), nitrogen (N), and organic matter (OM). **Figure 2.1.29** presents the common nickel laterite soil profile containing nickel, cobalt, Iron and Magnesium.

SCHEMATIC LATERITE PROFILE

COMMON NAME	APPROXIMATE ANALYSIS (%) Ni	Co	Fe	MgO
RED LIMONITE	<0.8	<0.1	>50	<0.5
YELLOW LIMONITE	0.8 to 1.5	0.1 to 0.2	40 to 50	0.5 to 5
TRANSITION	1.5 to 2	0.02 to 0.1	25 to 40	5 to 15
SAPROLITE/ GARNIERITE/ SERPENTINE	1.8 to 3		10 to 25	15 to 35
FRESH ROCK	0.3	0.01	5	35 to 45

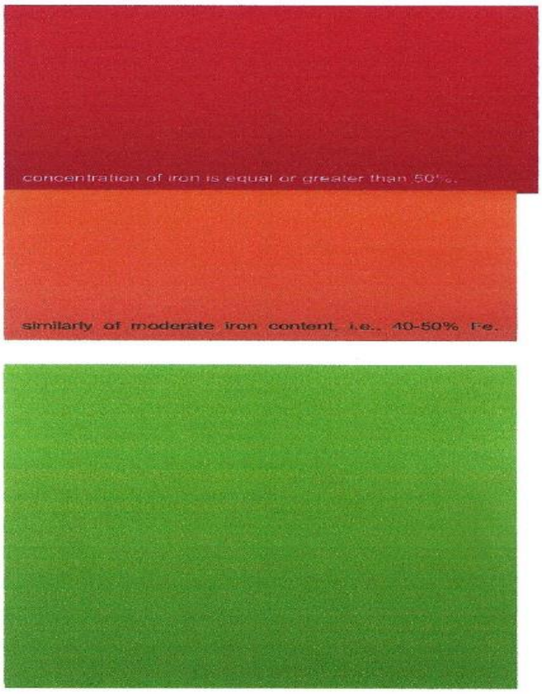


Figure 2.1.29: Common Nickel Laterite Soil Profile

The term pH is a numerical system to express the acidity of the soils. At pH 7.0, the soil is neutral and is neither acidic nor alkaline. Acidic soils have a pH value below 7.0 while soils with pH above 7.0 are alkaline.

Soil pH is one key factor in assessing the fertility of the soils. The degree of soil acidity on alkalinity as well as solubility and availability of essential nutrient elements for sustained plant growth can be inferred from soil pH.

Acidic soils do not only reduce phosphorous (P) availability but also promote iron (Fe) and manganese (Mn) toxicity. On the other hand, alkaline soil favors iron (Fe) and manganese (Mn) deficiency.

Very slightly acid to neutral pH is synonymous with fertile soil. Under this condition, the soil becomes most favorable for the availability of nutrients and microbial activities including nitrogen fixation by bacteria and faster decomposition of organic matter, which are essential to plant growth.

Organic matter (OM) affects soil fertility in terms of cation exchange capacity and nutrient supply. In general, the higher the organic matter content the higher is the cation exchange capacity supply of available nitrogen (N), phosphorous (P), and sulfur (S). The decomposition of organic matter brought about the release of acids that act on soil minerals resulting in the release of plant nutrients.

The addition of organic matter on soils increases its moisture content, cation exchange capacity, improves soil structure and water infiltration rates.

Nitrogen as a primary nutrient is found in chlorophyll, nucleic and amino acids, and a component of protein and enzymes in plants. Meanwhile, phosphorous is an essential component of DNA, RNA, and phospholipids which play critical roles in cell membranes and play a major role in the energy system of plants.

Potassium plays a major role in plant metabolism and is involved in photosynthesis, drought tolerance, and protein synthesis.

Manganese (Mn) is a plant micronutrient. It fulfills several roles and is used in photosynthesis, synthesis of chlorophyll, and nitrogen absorption. Ideally, for healthy and productive soil the concentration of manganese should be >1.0 %. The manganese (Mn) contents of the site fall under the deficient category.

Copper (Cu) is also a micronutrient and plays a range of roles in plants. It facilitates respiration and photosynthesis and is important for plant metabolism. It is a component of a variety of enzymes and plant cell walls so it is important for plant strength.

Preferably, for healthy and productive soil, the concentration of copper should be >0.2 but not exceed 50 mg/kg. Copper toxicity or excessive levels of copper in plants can inhibit iron uptake and can stunt growth. Excess soil copper can also inhibit seed germination.

The **zinc (Zn)** concentration of the site falls within adequate conditions. The ideal concentration of zinc in healthy and productive soil is >1.5 mg/kg up to 200 mg/kg. Zinc, similar to copper and manganese, is an essential plant micronutrient. It is important for the production of plant growth hormones and proteins and is involved in sugar consumption. Maintaining adequate zinc levels is important for enabling plants to withstand low air temperatures.

2.1.3.2.2 Soil Quality

Soils are the major sink for heavy metals released into the environment by natural processes such as weathering, and those from anthropogenic activities. Unlike organic contaminants that undergo oxidation by microbial action, most metals do not undergo microbial or chemical degradation, and their total concentration in soils persists for a long time after their introduction (Wuana, 2011).

Heavy metals constitute an ill-defined group of inorganic chemicals, and those most commonly found at sites are arsenic (As), cadmium (Cd), chromium hexavalent (Cr +6), mercury (Hg), and lead (Pb). **Table 2.1.9** presents the results of soil and sediment analysis for heavy metals.

Table 2.1.8: Results of Soil Analysis for Heavy Metals

RESULTS OF ANALYSIS

Sample Descriptions	Parameters	Results	Units	Methods
Soil Samples				
NDMRC-NDS1-A	pH [a]	5.5	-	Electrometric
	Moisture (as received)	25.51	%	ASTM D 2216 - 10
	Nitrogen (N)	0.1	%	Kjeldahl
	* Phosphate	0.092	%	Titrimetric
	Total Organic Matter	3.734	%	Walkley - Black (Colorimetric)
	Potassium (K) [b]	<0.20	mg/kg	Direct Air-Acetylene Flame
	* Cobalt (Co) [b]	20.36	mg/kg	Direct Air-Acetylene Flame
	Copper (Cu) [b]	9.78	mg/kg	Direct Air-Acetylene Flame
	Zinc (Zn) [b]	82.87	mg/kg	Direct Air-Acetylene Flame
CAA-SED2	Mercury (Hg) [c]	<0.08	mg/kg	Cold Vapor AAS
	* Sulfur (S)	0.070	%	Gravimetric
	* Hexavalent Chromium (Cr^{6+})	<0.10	mg/kg	Colorimetric
	Nickel (Ni) [b]	4392.74	mg/kg	Direct Air-Acetylene Flame
	Arsenic (As) [b]	<0.01	mg/kg	Manual Hydride Generation AAS
	Cadmium (Cd) [b]	<0.03	mg/kg	Direct Air-Acetylene Flame
	Lead (Pb) [b]	<0.10	mg/kg	Direct Air-Acetylene Flame
PAN-SED2	Mercury (Hg) [c]	<0.08	mg/kg	Cold Vapor AAS
	* Sulfur (S)	0.126	%	Gravimetric
	* Hexavalent Chromium (Cr^{6+})	<0.10	mg/kg	Colorimetric
	Nickel (Ni) [b]	1432.04	mg/kg	Direct Air-Acetylene Flame
	Arsenic (As) [b]	3.02	mg/kg	Manual Hydride Generation AAS
	Cadmium (Cd) [b]	<0.03	mg/kg	Direct Air-Acetylene Flame
	Lead (Pb) [b]	<0.10	mg/kg	Direct Air-Acetylene Flame
MAR-SED1	Mercury (Hg) [c]	<0.08	mg/kg	Cold Vapor AAS
	* Sulfur (S)	0.027	%	Gravimetric
	* Hexavalent Chromium (Cr^{6+})	<0.10	mg/kg	Colorimetric
	Nickel (Ni) [b]	6857.58	mg/kg	Direct Air-Acetylene Flame
	Arsenic (As) [b]	<0.01	mg/kg	Manual Hydride Generation AAS
	Cadmium (Cd) [b]	<0.03	mg/kg	Direct Air-Acetylene Flame
	Lead (Pb) [b]	<0.10	mg/kg	Direct Air-Acetylene Flame

Arsenic (As) is a toxic compound and it is most toxic in its inorganic form. It naturally occurs in the soil and elsewhere in the environment and it is the 20th most common element on Earth. The Dutch Soil Standards suggest that soil should have less than 29 mg of arsenic per kg of soil.

Cadmium (Cd) is a toxic element used in the manufacture of batteries and is found in cigarette smoke, some paints, soil zinc additives, some fertilizers (especially those that contain phosphorus), and some manures. The amount of cadmium in soils is generally low but once it has been added to the soil, it can take between 100 and 1000 years for the levels to drop by 50%. When cadmium is present in the soil, it is more available to plants if the soil is sandy, acidic, or low in organic matter. It is recommended that soil contain less than 0.8 mg of cadmium for every 1 kg of soil.

Chromium (Cr) is a naturally occurring element in rocks and soil. Natural soil typically contains between 10 and 50 mg of chromium for every kg of soil. Chromium is toxic in high amounts to both plants and humans but the toxicity depends on the valence; chromium hexavalent (Cr +6) being substantially more toxic.

Mercury (Hg) belongs to the same group of the periodic table with Cd. The release of Hg from coal combustion is a major source of Hg contamination. Mercury is most toxic in its alkylated forms (methyl/ ethyl mercury) which are soluble in water and volatile in air.

Lead (Pb) is a naturally occurring heavy metal. It is, however, toxic to plants and humans. Soil may become contaminated with lead if it is exposed to any of these substances or processes or if water runoff from such substances infiltrates the soil. Lead in the soil does not biodegrade nor does it leach easily so even structures that have had all lead paint removed may have lead-contaminated soil in this area as a result of previous exposure.

2.1.3.3 Soil Erodibility

Erosion susceptibility can be defined as the degree to which a certain area is likely to be affected by erosion. The susceptibility of soils to erosion is influenced by many factors such as soil texture, structure, internal soil drainage, degree and length of slopes, vegetative cover, management practices and amount, frequency, and distribution of rainfall. Little can be said with certainty about the extent to which these factors, either singly or in combination, affect the degree of soil erosion in the project site.

According to the Soil Survey of Surigao del Sur Province Report of BSWM, there are two classes of erosion that are recognized in the area: Class 1 is none to slight degree of erosion. It occurs at the upper 15-20 cm of the surface layer that exhibits the A horizon characteristics of Kabatohan Series. On the other hand, Class 2 is a moderate degree of erosion and is characterize by erosion at the upper 15-20 cm of the surface layer that exhibits characteristics of both A and B-horizons.

Mostly, mountainous areas thickly covered with secondary and primary forests are not much affected by erosion even if it has a slope of greater than 25%. This condition is exhibited at the midsection and northwest flank of the MPSA site.

Likewise, hilly areas just like in the northwest of the project site and even the foot slope vegetated with shrubs and grasses are not or less affected by erosion. Steep to very steep areas north of the project site covered with ferns and patches of bonsai trees are more severely affected by erosion during the rainy season probably due to the kind of soil and vegetative covers.

2.1.3.4 Soil Erosion / Loss of Topsoil/ Overburden

Land degradation may result from stripping of the topsoil and excavation to expose the rock strata. This will tamper with the soil structure exposing the site to possible landslides and soil erosion as well as interrupting the continuity of open space. Surface erosion and down slope sedimentation may increase in relation to mine-related activities. Similarly, earthworks, construction activities, and movement of heavy equipment will weaken the soil and induce the natural erosion susceptibility of the soil cover, particularly in areas with >18% slopes.

Mitigating measures to be implemented by the proponent will include treating the bench faces by initializing stabilization of the pits walls through stepping of the faces to prevent erosion. This also reduces the risk of loose boulders (if there's any) falling from bench faces during blasting; restoring the affected areas through rehabilitation of decommission pits and planting of indigenous plant species which create a stable final landform with acceptable post-mining land use capability.

Establishment of the pits, settling pond, and stockyards will result in generation of overburden comprised of top soils, vegetation, and rock rumble. If inappropriately disposed, the overburden becomes an eyesore apart from harboring insects and disease causing vectors. To mitigate this impact reusing overburden as backfilling material during site rehabilitation and restoration will be employed. Restoration of disturbed areas where applicable will be in accordance with the project's FMRDP. This includes progressive soil cover rehabilitation and slope grade management.

Lastly, an Erosion and Sediment Control Plan (ESCP) will be prepared and implemented to manage erosion and sedimentation in all active and rehabilitated areas to minimize sediment deposition into the various surface water bodies that drain the project site.

2.1.3.5 Change in Soil Quality/ Fertility

The fertility and quality of soil and sediments within the project site will be affected due to passage of vehicles and heavy equipment, above all, development and operation of the area over the course of the project.

The major sources of potential soil contaminants within the projects site will be the electric cables and fuses, storage areas, diesel fuel tanks, and chemical storage tanks. Off-site adverse impacts are not expected since these will be located inside the mining areas.

Utilization of closed transport and storage system, storage tank bunds, and emergency response procedures will minimize soil contamination from these sources.

Lastly, waste products such as oil and lubricants shall be properly handled, stored and disposed in accordance with the existing DENR guidelines. Hazardous materials and wastes shall be contained in areas with lining or in storage tanks. Safety procedures shall be implemented to avoid spillage by installation of auto shutoff valves in the refueling and lubricating stations. In case of accidental spills, contaminated soil shall immediately be removed to avoid further dispersion of contaminant.

2.1.4 Terrestrial Ecology

2.1.4.1 Terrestrial Flora

Patch sampling technique was done to assess the floral composition of the site. Sampling stations were laid on different vegetative communities observed on the area. Both line-intercept and nested quadrat technique were used to describe the vegetation of the site. Line intercept technique were used in areas of grasslands and shrubs, those areas with known tree stands were assessed using nested-quadrat technique. All of the species observed were listed for the over-all species composition of the site.

All plant habits were covered by the assessment, including large woody trees, shrubs, herbs, vines and ferns. For the portions with large predominant mature trees, nested quadrat technique was conducted. In these areas, a 10m x 10m quadrats were laid and all trees with diameter-at-breast-height (DBH) of greater than or equal to 110m were included in the list for the computation of the Importance Value (IV). A nested plot of 5m x5m quadrat were established inside the original plot to assess the smaller trees and plants with DBH of less than 10cm for the identification of saplings and understory diversity of the area. Line intercept method was done in areas with relatively sparse canopy and immense forest floor cover such as ferns and herbs. All of the methods conducted were in accordance with the Biodiversity Assessment and Monitoring System (BAMS) produced by the DENR.

Quantitative descriptions of the floral assemblage were done after the on ground assessment. Importance Values of trees were computed using the series of formula:

a) $Relative\ Density\ (RD), in\ \% = \frac{Number\ of\ Individuals\ in\ a\ Species}{Total\ Area\ Sampled}\ x\ 100\%;$

b) $Relative\ Frequency\ (RF), in\ \% = \frac{Number\ of\ Samples\ in\ which\ Species\ Occur}{Total\ Number\ of\ Sampling\ Plots}\ x\ 100\%;$

c) $Relative\ Dominance\ (RDom), in\ \% = \frac{Total\ Basal\ Area\ of\ Species}{Total\ Area\ Samples}\ x\ 100\%;$

d) $Importance\ Value\ Index\ (IVI) = \sum(RD + RF + RDom)$

Diversity indices were also computed to describe the biodiversity in the area. Indices calculated were as follows:

a.) Shannon-Weiner Index
b.) Pielou's Evenness Index

The proposed project site is composed of varied forest types present in the area. This includes secondary closed-canopy forest, which are generally located in the upper portion of the parcel, patches of ultramafic forests in the middle portion and scattered brushlands in the edges of the area. The project site is generally characterized by steep slopes with varied plant family cover. Several secondary river system runs across the edges of the proposed project site that hosts lengths of riparian ecosystem predominantly covered by sedges and herbs.

A total of eight (8) stations were assessed on the area that covers the varied the mentioned forest cover types. Seven stations were assessed on the actual proposed mining site. One (1) station was allotted for the mangrove ecosystem in the port area. All stations were assessed with three (3) replicate plots each. **Figure 2.1.29** shows the location of the sampling stations and **Table 2.1.10** shows the specific location and description of each station.

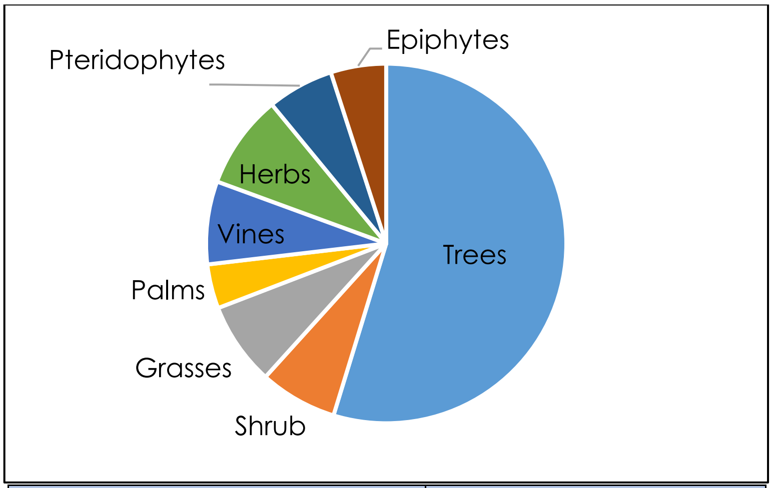
Table 2.1.9: Description of Terrestrial Flora Survey Stations

Stations	Coordinates	Elevation	Description
1	9°24'17.67"N 125°50'40.90"E	546 masl	Secondary forest with notable dipterocarp species covering the canopy. Canopy cover dense to semi-dense.
2	9°24'28.79"N 125°51'4.49"E	524 masl	Closed canopy secondary forest with abundance of Myrtaceae species.
3	9°25'0.88"N 125°51'4.50"E	411 masl	Nearby riverine ecosystem, dense to semi-dense canopy cover with significant understory species cover.
4	9°25'25.57"N 125°50'44.05"E	736 masl	High elevation area with closed canopy, mosses abundant in the trunks and leaves of plant species observed.
5	9°25'28.38"N 125°51'20.42"E	728 masl	High elevation area with closed canopy, mosses abundant in the trunks and leaves of plant species observed.
6	9°23'42.47"N 125°51'15.86"E	542 masl	Open to semi-dense canopy cover of short trees. Significant lateritic substrate typical of a forest over ultramafic soils.
7	9°23'48.21"N 125°51'28.51"E	501 masl	Open to semi-dense canopy cover of short trees. Significant lateritic substrate typical of a forest over ultramafic soils.
8	9°24'24.99"N 125°54'21.29"E	5 masl	Mangrove area were the proposed project will conduct shipment.

Figure 2.1.29: Location Map of Terrestrial Flora Survey Stations

2.1.4.1.1 Species Composition

A total of 202 species belonging to 79 plant families were identified in the area. These species represent different plant habits as summarized in **Figure 2.1.30**. Species composition of the area was derived on the over-all listing of all plant species encountered, this means that plants seen along the trail of the proposed project site, but not inside the quadrats established were also included.



General Plant Habits	Number of Species
Trees	110
Shrub	14
Grasses	15
Palms	8
Vines	15
Herbs	17
Pteridophytes	12
Epiphytes	10

Figure 2.1.30: Summary of Plant Habits Identified in the Area

Family Myrtaceae is the most represented Family notably the Genus *Syzygium* (**Figure 2.1.31**). These tree species are present in all upland stations assessed. Family Moraceae is the next with the most number of species. Both families are common to dominate tropical forests in terms of number of species which is accounted mainly to its diversification in tropical rainforest. Family Nepenthaceae, an herbaceous vine producing carnivorous pitfall traps was also found in all upland stations assessed.

Tree species are observed to dominate the area in terms of species richness. Configuration of the understory varies. Several brush species consisting shrubs and herbs were found to be in high species count in areas with thick forest floor vegetation such as Stations 2 and 3. Together with grasses and ferns, shrubs and herbs are pioneer species in rehabilitation and are essential in keeping microclimate inside the forest area.

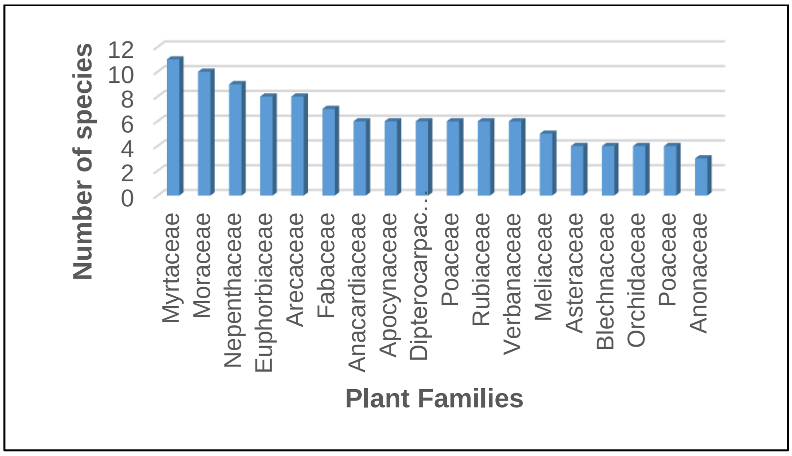


Figure 2.1.31: Plant Families with the Most Number of Species Observed on the Survey Stations

Plate 2.1.7: Proposed Site with Mixture of Densely and Moderately Covered Secondary Forest with Patches of Areas Covered with Plants Thriving in Ultramafic Soils

2.1.4.1.2 Importance Values

Importance Values (IV) is an important quantitative description that gives idea what species of trees have the most effects on the ecological function of a given landscape. Higher IV indicates that a tree has a high role on important forest processes such as nutrient cycling and carbon sequestration.

In computation of the IV, only the tree species (DBH ≥ 10 cm) inside the established sampling plots were included. Importance value is a summation of three separate values namely, Abundance, Dominance and Frequency. Values of each tree relative to the values of the other tree species were computed and added to derive the Importance Value.

Density is the total number of individuals of each species in all the quadrats divided by the total size of quadrats studied. Density is calculated by the equation: Relative density measures the density of the plant species in all of the quadrat assessed. It is the numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

Frequency refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence. Relative frequency compares the absolute frequency of a species to the frequencies of all species found on the plots. It is the degree of dispersion of individual species in an area in relation to the number of all the species occurred. This can be calculated using the formula:

Dominance of a species is determined by the value of the basal cover while relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

Summation of the three relative values derives the Importance Values of each tree species. **Table 2.1.11** shows the complete list of trees with the highest importance values.

Table 2.1.10: List of Trees with High Importance Values

Rank	Species	Family	Common Name	IV
1	*Cederla ododrata L.*	Meliaceae	Cedar	15.12%
2	*Leptospermum amboinense*	Myrtaceae	Payospos	15.01%
3	*Tristania decorticata*	Myrtaceae	Malabayabas	14.25%
4	*Shorea negrosensis*	Dipterocarpaceae	Red Lauan	14.18%
5	*Casuraina equisetifolia*	Casuarinaceae	Agoho	12.23%
6	*Syzygium brevistylum*	Myrtaceae	Sagimsim	11.92%
7	*Shorea astylos*	Dipterocarpaceae	Yakal	11.54%
8	*Shorea contorta*	Dipterocarpaceae	White lauan	11.01%
9	*Artocarpus blancoi Merr.*	Moraceae	Antipolo	10.94%
10	*Ficus ulmifolia L.*	Moraceae	Ficus	10.90%
11	*Macaranga tanarius (L.) Müll.Arg.*	Euphorbiaceae	Binunga	10.84%
12	*Antidesma ghaesembilla Gaertn.*	Phyllantaceae	Binayuyo	10.52%
13	*Steblus asper Lour.*	Moraceae	Kalyos	10.24%
14	*Hopea foxworthyi*	Dipterocarpaceae	Dalingdingan	9.84%
15	*Tremna orientalis*	Cannabaceae	Anabiong	9.25%
16	*Wrightia pubescens R. Br*	Apocynaceae	Lanete	9.21%

The tree species with the computed highest relative density (8.02%) is *Cederla odorata* indicating that this species is the most commonly found among the sampling plots in each station. *C. odorata* also has the highest dominance (5.04%), this means that the species covers the most basal area in reference with the total sampling size of all the sampling plots established. Payospos, (Leptospermum amboinense) has the highest frequency. This means that Payospos is the present in most of the plots assessed. In this assessment, Payospos is present in all assessed plots.

It has to be noted that in this assessment, the highest IV computed (15.12%) is low given the diversity of tree species present. This means that no specific plant dominates the area and a diverse array of tree species are interacting, thus providing a relatively even distribution of Importance Values.

Plate 2.1.8: Payospos (Leptospermum Amboinense) Found Thriving Over Ultramafic Soils in the Edges of the Proposed Project Site

2.1.4.1.3 Diversity Indices

The biodiversity of the area was described using two indices; Shannon-Weiner Index and Pielou's Evenness Index. The Shannon-Weiner Index (J') assumes that individuals are randomly samples from a large population and that all species are represented in the sample. It is an estimate of species richness and distribution. Pielou's Evenness Index, on the other hand, shows how diversed or even is the distribution of each species in a given location.

Shannon-Wiener Diversity Index (H) is calculated using the formula below and the result was compared to the Modified Fernando Biodiversity Index to obtain the relative value of the diversity. This index measures the diversity of the area using the number of species present.

$$H' = \sum_{i=1}^{S} pi \ln pi$$

Where;
H' = Species diversity index
S = The number of species
Pi = The proportion of individuals of each species belonging to the ith species of the total number of individuals

Pielou's Species Evenness Index is another biodiversity index used to describe how evenly distributed the species in the study area are. This can be calculated using the formula,

$$J' = \frac{H'}{H'_{max}}$$

Where:
J' = Species evenness
H' = Computed Shannon-Weiner Index
H'max = lnS
S = Species richness

The computed values can be interpreted using the Fernando's Biodiversity Scale which is elaborated on **Table 2.1.12**.

Table 2.1.11: Fernando's Biodiversity Scale

Relative Values	Shannon-Weiner Index (H')	Evenness
Very High	3.50 – 4.00	0.75 – 1.00
High	3.00 – 3.49	0.50 – 0.74
Moderate	2.50 – 2.90	0.25 – 0.49
Low	2.00 – 2.49	0.15 – 0.24
Very Low	1.99 and below	0.14 and below

Generally, Philippine tropical forest has a high diversity of species. However, depending on the actual species composition of a specific area, a varied value of diversity indices is expected. In the case of the proposed site, the variety of forest covers present reflected on the values of the biodiversity indices. Computed values are shown in **Figures 2.1.32** and **2.1.33**.

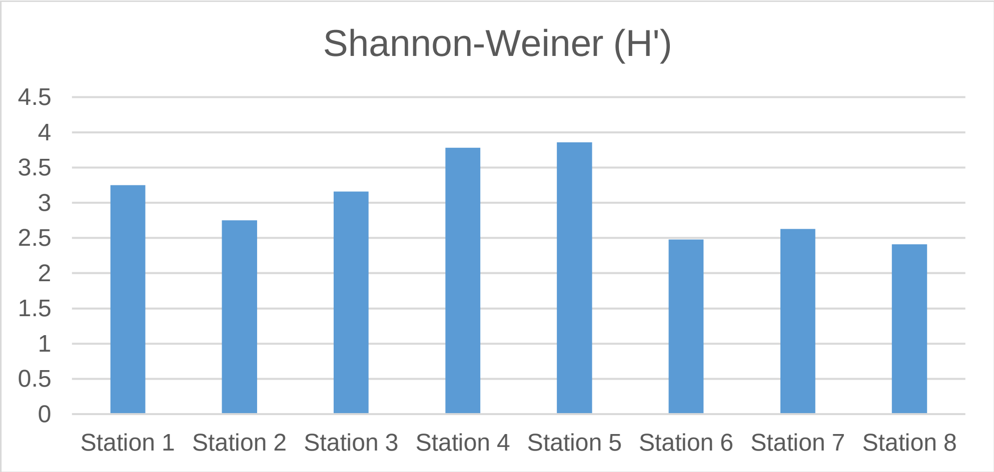


Figure 2.1.32: Computed Shannon-Weiner Index (H') of the Survey Stations

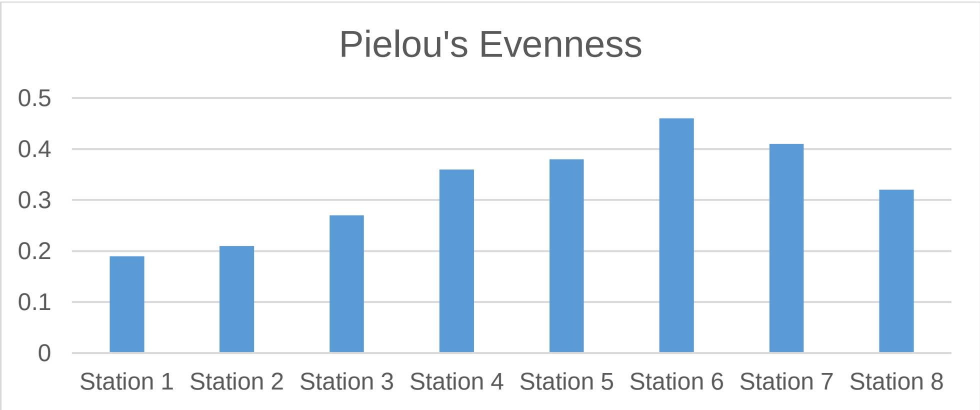


Figure 2.1.33: Computed Pielou's Evenness Values of the Survey Stations

Highest H' value was computed on Stations 5 (3.86) and Station 4 (3.76), both of which translates to "Very High" diversity as described in Fernando's biodiversity scale. Lowest H' values were on Station 6 and 7 with 2.41 translating to "Low" diversity. It has to be noted that this station is predominantly covered by Payospos (23 individuals). Higher frequency of a species in a location compared to other species results to lower species evenness values. Stations 6-8 are dominated by species that can thrive in ultramafic soil conditions, compared to other stations, lower number of species were observed on the area. Station 8, which is a lowland mangrove swamp near the depot also has a low biodiversity. Given the limited number of species that can thrive in saline conditions, it is expected that mangrove swamps have low diversity.

2.1.4.1.4 Understory Diversity

The ground cover of the forest floor including the epiphytic plants were also assessed based on their species composition and dominance. On the stations assessed, notable understory species includes pitcher plants, ground orchids, ferns and grass species. List of understory species observed is on **Table 2.1.13**.

Table 2.1.12: Epitphytes and Pteridophytes observed on the Survey Stations

Family	Scientific name	Common Name
Epiphytes		
Nepenthaceae	*Nepenthes alata*	Pitcher plant
Nepenthaceae	*Nepenthes philippinensis*	Pitcher plant
Nepenthaceae	*Nepenthes surigaoensis*	Pitcher plant
Nepenthaceae	*Nepenthes mindanaoensis*	Pitcher plant
Nepenthaceae	*Nepenthes peltata*	Pitcher plant
Nepenthaceae	*Nepenthes mirabilis*	Pitcher plant
Nepenthaceae	*Nepenthes merilliana*	Pitcher plant
Brachytheciaceae	*Eurhyncium praelongum*	Feather Moss
Fissidentaceae	*Fisssidens taxifolius*	Pocket Moss
Funariaceae	*Funaria hydrometrica*	Cord Moss
Loranthaceae	*Loranthus philippinensis*	Mistletoe
Orchidaceae	*Dendrobium sp.*	Orchid
Orchidaceae	*Phalaenopsis aprhodite*	Mariposa
Orchidaceae	*Spatholottis plicata*	Ground Orchid
Orchidaceae	*Vanda sanderiana*	Wild Waling-waling
Pottiaceae	*Tortula muralis*	Tortula Moss
Thuidiaceae	*Thiudium tamiscinum*	Tamarisk moss
Pterophytes/Ferns		
Aspleniaceae	*Asplenium nidus*	Pakpak Lawin
Blechnaceae	*Blechnum oriente L.*	Pakong Alakdan
Blechnaceae	*Blechnum fraseli L.*	Pako-pako
Blechnaceae	*Stenochalaena milnei Underw.*	Hagnaya
Blechnaceae	*Stenocha palustris*	Diliman
Cyatheaceae	*Cyathea contaminans (Hook.)*	Tree fern/Anotong
Gleicheniaceae	*Dicranopteris linearis (Brum.f.)*	Agsam
Gleicheniaceae	*Gleichenia linearis Burm*	Kilob
Lycopodiaceae	*Lycopodium cernuum L.*	Clubmoss
Polypodiaceae	*Athyrium esculentum*	Pako
Psilotaceae	*Asplenium nidus Linn.*	Birds's nest fern
Selaginellaceae	*Selaginella delicatula (Desv.) Alston*	Spikemoss

Understory species are important in maintaining the microclimate of the forest floor and for water retention services. The abundance of the understory species suggest that the forest floor is suitable of providing more resources for the faunal species thriving in the area.

Shrubs and brush species were also assessed. **Table 2.1.14** shows the dominant shrubs and saplings that are encountered on the sampling stations based on the number of individuals per plot. Saplings included in the area are young tree species with less than 10cm DBH.

Table 2.1.13: Most Dominant Shrubs and Saplings on Each Upland Station

Station	Most Dominant Shrub	Most Dominant Saplings
1	*Melastoma malabatrichium*	*Leptospermum amboinense*

2	*Melastoma malabatrichium*	*Leptospermum amboinense*
3	*Eurycoma longifolia*	*Tristania decorticata*
4	*Melastoma malabatrichium*	*Ficus variegata*
5	*Melastoma malabatrichium*	*Casuraina equisetifolia*
6	*Eurycoma longifolia*	*Casuraina equisetifolia*
7	*Carmona retusa*	*Gymnostoma rumphianum*

2.1.4.1.5 Endemism

Endemic species are species found only in the Philippines or in a specific Philippine locality. Of the 201 species observed, 41 were found to be endemics. These species are important species in terms of conservation because of their novelty and generally lesser extent of their biogeographic distribution. **Table 2.1.15** lists all the endemic species found in the proposed site, both inside the sampling sites and along the trails.

Table 2.1.14: Endemic Species Recorded at the Survey Stations

Family	Scientific Name	Local/Common Name
Alangiaceae	*Alanguim meyerii*	Putian
Apocynacea	*Wringhtia laniti*	Lanete
Bignoniaceae	*Cordia dichotoma*	Anonang
Combretaceae	*Terminalia microcarpa*	Kalumpit
Dilleniaceae	*Dillenia philippinensis*	Katmon
Dipterocarpaceae	*Shorea astylosa*	Yakal
Dipterocarpaceae	*Shorea contorta*	White Lauan
Dipterocarpaceae	*Shorea guijo*	Guijo
Dipterocarpaceae	*Shorea negrosensis*	Red Lauan
Dipterocarpaceae	*Shorea palosapis*	Mayapis
Clusiaceae	*Calophyllum blancoi*	Bitanghol
Melastomotaceae	*Melastoma polyanthia*	Malatungo
Fabaceae	*Parkia roxburgil*	Kupang
Moraceae	*Ficus minahassae*	Hagimit
Moraceae	*Ficus variegata*	Tangisang bayawak
Myristicaceae	*Myristica philippinensis*	Duguan
Myrtaceae	*Tristania micrantha*	Tiga
Myrtaceae	*Tristania decorticata*	Malabayabas
Myrtaceae	*Xanthostemon verdugonianus*	Magkono
Rubiaceae	*Nauclea formicaria*	Hambabalod
Rubiaceae	*Canthium dococcum*	Malakape
Sonneratiaceae	*Duabanba moluccana*	Loktob
Sterculaceae	*Tarrieta sylavatica*	Dungon
Sterculaceae	*Tarrieta sylavatica*	Dungon
Urticaceae	*Mussaenda philippica Merr.*	Boyon
Verbanaceae	*Prema odorata blancoi*	Alagau
Verbanaceae	*Teijsmanniodendron ahernianum*	Kulipapa
Verbanaceae	*Callicarpa formosana Rolfe*	Tambabasi
Schizaceae	*Lygodium flexuosum*	Nito
Arecaceae	*Caryota cumingii Lodd.*	Pugahan
Arecaceae	*Calamus merrillii Becc.*	Rattan (Palasan)
Arecaceae	*Corypha utan Lamk.*	Buri
Palmae	*Calamus ornatus Blume*	Limuran
Pandanaceae	*Pandanus tectorius*	Baliw
Pandanaceae	*Freycinetia auriculata Merr.*	Freycinetia
Pandaceae	*Freycinetia auriculata Merr.*	Freycinetia
Melastomotaceae	*Melastoma malabathricum L.*	Hantutuknaw/malarungao
Nepenthaceae	*Nepenthes philippinensis*	Pitcher plant
Nepenthaceae	*Nepenthes surigaoensis*	Pitcher plant
Nepenthaceae	*Nepenthes mindanaoensis*	Pitcher plant
Cyatheaceae	*Cyathea contaminans*	Anotong

Sapling diversity is a result of the success of germination of the existing mature trees. A dominance of a certain species indicates its success on ensuring next generation of trees that will succeed the parent plant, if the sapling survives.

Plate 2.1.9: Melastoma malabathrichium (left) and Eurycoma longifolia (right) are among the most common understory shrubs found in the survey stations

Vine species are dominated by pitcher plants. In all sampling plots, an individual from the family Nepenthaceae is present. The diversity of *Nepenthes* species indicates lateritic soil contents in the area, a common feature in the Caraga mountains. Observed pitcher plant species varies in terms of habits, some remains procumbent producing its lower pitcher, while some are herbaceous epiphytic vines producing its upper pitchers.

Plate 2.1.10: Upper pitcher of N. philippinensis (Left) and lower pitcher of N. surigaoensis (right), both of which are endemic species to the Philippines

2.1.4.1.6 Coastal flora

Station 8 is solely allotted for the mangrove vegetation nearby the proposed port area. Three plots were assessed ensuring the representation of mangrove zonation using belt transect method. Most dominant species assessed is bakawang lalake (*Rhizophora apiculata*). Other dominant species found during the assessment is pagatpat (*Sonneratia alba*) and tabao (*Lumnitzera littorea*).


Plate 2.1.11: Rhizophora apiculata (Left) and flowering Lumnitzera littorea (Right) both found in abundance in Station 8 near the proposed port

Mangrove forests are different in upland forest species because of their ability to survive saline environment. These mangrove forest located in the port area serves as a connection of the upland forest assessed and the nearby marine ecosystem. Mangroves function on sediment accretion of the coast where their specialized roots are highly adapted.

As mentioned, Station 8 has the low biodiversity in terms of Shannon-Winer Index. This is characteristic of many mangrove forest since only few species are adaptive of the coastal conditions.

2.1.4.1.7 Conservation Status

Conservation status of all plant species encountered were determined using local and international guidelines. These guidelines include International Union for the Conservation of Nature (IUCN) Red list of threatened species and DENR Department Administrative Order (DAO) 2017-11 Updated National List of Threatened Philippine Plants and their Categories.

For the DAO 2017-11, the categories are Critical (CR), Endangered (EN), Vulnerable (VU) and Other Threatened Species (OTS). For the IUCN Red list, categories include Least Concern (LC), Near Threatened (NT), Vulnerable (VU), while others are data deficient (DD). Species may be vulnerable in the local checklist, but global population are in decline. At the same time, global population may be stable for some species, but the local population in the Philippines are declining. This explains why there are several species that are considered vulnerable in one checklist, but Least Concern (LC), or not included on the other.

For the project site, there are 38 species identified with a flagged conservation status in either or both of the local and international checklist assessed. It has to be noted that the conservation status of the species that found in the area covers multiple plant families and plant habits. The threats on the population in the plant species are not limited to trees only but also understory and epiphytic species such as pitcher plants and orchids that are abundant in the area.

Table 2.1.15: List of species with existing conservation status in DAO 2017-11 and IUCN Redlist

Family	Scientific Name	Common Name	DAO 2017-11	IUCN
Anacardiaceae	*Mangifera monandra*	Mangapaho	VU	NT
Anacardiaceae	*Mangifera altissima*	Pahutan	None	DD
Apocynacea	*Kibatalia gitingensis*	Laneteng gubat	None	NT
Apocynacea	*Voacanga globosa*	Bayag-usa	None	LC
Apocynacea	*Wringhtia laniti*	Lanete	None	None
Dilleniaceae	*Dillenia philippinensis*	Katmon	None	NT
Dipterocarpaceae	*Shorea almon*	Almon	VU	NT
Dipterocarpaceae	*Hopea foxworthyi*	Dalingdingan	None	EN

Family	Scientific Name	Common Name	DAO 2017-11	IUCN
Dipterocarpaceae	*Shorea astylosa*	Yakal	CR	EN
Dipterocarpaceae	*Shorea contorta*	White Lauan	VU	LC
Dipterocarpaceae	*Shorea negrosensis*	Red Lauan	VU	LC
Lauraceae	*Cinnamomum mercadoi*	Kalingag	OTS	LC
Lauraceae	*Litsea leytensis*	Batikuling	EN	NT
Meliaceae	*Toona calantas*	Kalantas	VU	DD
Moraceae	*Artocarpus rubrovenius*	Kalulot	OTS	None
Myrtaceae	*Syzygium claviflorum*	Kurasan	None	LC
Myrtaceae	*Syzygium costulatum*	Paitan	None	VU
Myrtaceae	*Syzygium nitidum*	Makaasim	VU	LC
Myrtaceae	*Rhodomyrtus surigaoensis*	Payuspos	None	EN
Myrtaceae	*Xanthostemon verdugonianus*	Magkono	EN	VU
Orchidaceae	*Vanda sanderiana*	Wild Waling-waling	CR	None
Palmae	*Calamus merrillii Becc.*	Rattan (Palasan)	OTS	None
Palmae	*Calamus ornatus Blume*	Limuran	OTS	None
Nepenthaceae	*Nepenthes peltata*	Pitcher Plant 1	CR	None
Nepenthaceae	*Nepenthes merrilliana*	Pitcher Plant 2	CR	VU
Nepenthaceae	*Nepenthes philippinensis*	Pitcher Plant 3	EN	None
Nepenthaceae	*Nepenthes surigaoensis*	Pitcher Plant 3	EN	None
Dipterocarpaceae	*Shorea polysperma*	Tanguile	VU	LC
Meliaceae	*Toona calantas Merr.*	Kalantas	VU	None
Dipterocarpaceae	*Hopea foxworthyi*	Dalingdingan	None	EN
Dipterocarpaceae	*Shorea astylosa*	Yakal	CR	EN
Myrtaceae	*Syzygium nitidum*	Makaasim	VU	LC
Myrtaceae	*Xanthostemon verdugonianus*	Magkono	EN	VU
Lauraceae	*Litsea glutinosa*	Batikuling	None	LC
Nepenthaceae	*Nepenthes peltata*	Pitcher Plant	CR	None
Anacardiaceae	*Mangifera monandra*	Pahutan	VU	NT
Moraceae	*Artocarpus blancoi*	Antipolo	None	LC
Cyatheaceae	*Cyathea contaminans*	Tree fern/Anotong	EN	LC
Lauraceae	*Cinnamomum mercadoi*	Kalingag	OTS	LC

2.1.4.2 Terrestrial Fauna

Assessment and monitoring of fauna is important especially in mining areas because some species serves as indicator of ecological condition of a certain habitat. Some species are dependent on a particular species, some are indicators of pollution and some are sensitive to habitat fragmentation. Knowing the species and their status in a particular area will give an insight on the suitability of the rehabilitated area to host and sustain biodiversity.

Transect walk which includes ocular inspection, Bioacoustics, and search for tracks, fecal samples, remains and disturbances was conducted to obtain maximum data on the species present in an area.

A transect line within the area of study was delineated. It was employed in a paved trail way or established new path with a standard pacing of 1 km per hour. The standard transect in avifaunal studies which is 2-3 km was followed. The observation paths were plotted along different land uses present in the mining area. Conduct of the transect were done at 6-8 in the morning and 4-6 in the afternoon. Identification and count of all the species seen or heard were done on either sides of the transect towards the distance where species were still detectable or within a fixed distance from the observer.

Table 2.1.16: Description of Terrestrial Survey Stations

Transect	GPS Coordinates	Elevation (masl)	Site Description
1	09º 24' 17.67" N 125 º 50' 40.90" E	546	Sitio Tabok, Brgy. Pantukan, Carrascal Surigao del Sur
2	09º 24' 29.31" N 125º 51' 4.50 E	524	Sitio Asinan, Brgy. Pantukan

3	09° 25' 0.88" N 125° 51' 4.50 E	411	Upper Marga River, Brgy. Pantukan,
4	09° 25' 14.55" N 125° 50' 46.33 E	736	Brgy. Pantukan, Carrascal Surigao del Sur
5	09° 25' 14.95" N 125° 51' 18.03 E	736	Upper Kaayungan, Brgy. Adlay, Carrascal Surigao del Sur
6	09°23'41.25" N 125°51'18.72" E	640	Brgy. Pantukan, Carrascal Surigao del Sur
7	09°24'24.99" N 125°54'21.29"E	-	Port Area, Brgy. Adlay, Carrascal Surigao del Sur

2.1.4.2.1 Species Composition

A total of 71 species belonging to 64 genus and 42 families of birds, mammals, reptiles and amphibians were observed within the project site (**Table 2.1.18**). The location of the site is within the Mindanao faunal group, one of the largest in the country and harbors a great number of faunal species. In addition, it is located within the boundaries of Mt. Hilong hilong which is considered as an Important Bird Area (BirdLife International, 2021). The assessment was conducted in the mountain ranges in Carrascal Surigao del Sur at elevations up to 736masl. In comparison with known/recorded species, about 15.5% and 9.2% of bird species in Mindanao and Philippines, respectively, were observed in the site. For other faunal groups, about 9.5 - 10% of Mindanao species and 3.7-4.2% of Philippine species were identified in the site (**Table 2.1.19**).

Table 2.1.17: Summary of the Number of Species, Genus and Families Observed per Faunal Group

Faunal Group	No. of Species	No. of Genus	No. of Families
Birds	51	44	26
Mammals	8	8	7
Reptiles	8	8	6
Amphibians	4	4	3
TOTAL	**71**	**64**	**42**

Table 2.1.18. Faunal Species Observed in the Survey Stations in Comparison with Known Species of Mindanao and the Philippines

Faunal Group	Number of Species		% Site to Mindanao	% Site to Philippines
	Mindanao	Philippines		
Birds	327a	552b	15.5%	9.2%
Mammals	-	214c	-	3.7%
Reptiles	84d	196b	9.5%	4.0%
Amphibians	40d	95b	10%	4.2%

Note: aPeterson et al., 2000; bDENR-PAWB, 2013; cHeany et al., 2010; dSanguila et al., 2016;

The assessment was conducted in two (2) periods: January 2015 and April 2021. **Table 2.1.20** shows the checklist of birds, mammals, reptiles and amphibians that were identified based from visual encounters, sounds and presence of fecal samples, foot tracks, nests and holes. A total of 51 and 52 species were observed in 2015 and 2021 assessments, respectively. In 2015, a total of 35 birds, six (6) mammals, seven (7) reptiles and three (3) amphibians were identified. In comparison with the 2021 assessment, were a total of 36 birds, seven (7) mammals, six (6) reptiles and three (3) amphibians were noted.

Table 2.1.19: Checklist of Birds, Mammals, Reptiles and Amphibians Observed during the 2015 and 2021 Assessments

No.	Scientific Name	Common Name	2015	2021
Birds				
1	*Aplonis panayensis (Scopoli, 1783)*	Asian glossy starling	✓	✓
2	*Ardea Ibis* (Linnaeus, 1758)	Cattle egret	✓	
3	*Artamus leucoryn* (Linnaeus, 1771)	White-breasted woodswallow	✓	✓
4	*Butorides striata* (Linnaeus, 1758)	Striated Heron		✓
5	*Cacomantis merulinus* (Scopoli, 1786)	Plaintive Cuckoo		✓
6	*Centropus bengalensis* (Gmelin, 1788)	Lesser coucal	✓	✓
7	*Centropus viridis (Scopoli, 1786)*	Philippine coucal	✓	✓
8	*Ceyx lepidus (Temminck, 1836)*	Variable dwarf-kingfisher	✓	
9	*Ceyx mindanensis (Steere, 1890)*	Philippine dwarf-kingfisher	✓	
10	*Chalcophaps indica* (Linnaeus, 1758)	Emerald Dove	✓	
11	*Chrysocolaptes guttacristatus* (Tickell, 1833)	Greater flameback	✓	
12	*Cinnyris jugularis* (Linnaeus, 1766)	Olive-backed sunbird	✓	✓
13	*Circus melanoleucos* (Pennant, 1769)	Pied Harrier	✓	
14	*Collocalia esculenta* (Linnaeus, 1758)	Glossy Swiftlet	✓	✓
15	*Collocalia troglodytes* (Gray, 1845)	Pygmy swiftlet		✓
16	*Corvus enca (Horsfield, 1822)*	Slender-billed crow	✓	
17	*Corvus Macrorhynchos* (Wagler, 1827)	Large-billed crow		✓
18	*Dicaeum australe* (Hermann, 1783)	Red keeled flowerpecker		✓
19	*Dicaeum bicolor (Bourns & Worcester, 1894)*	Bicolored flowerpecker		✓
20	*Dicaeum trigonostigma* (Scopoli, 1786)	Orange-bellied Flowerpecker		✓
21	Egretta garzetta (Linnaeus, 1766)	Little egret		✓
22	*Gallus gallus* (Linnaeus, 1758)	Red Jungle Fowl	✓	
23	*Geopelia striata* (Linnaeus, 1766)	Zebra dove	✓	✓
24	*Halcyon gularis* (Kuhl, 1820)	White-throated Kingfisher	✓	✓
25	*Haliaeetus leucogaster (Gmelin, 1788)*	White-bellied sea-eagle	✓	
26	*Haliastur indus* (Boddaert, 1783)	Brahminy Kite		✓
27	*Hypotaenidia torquata* (Linnaeus, 1766)	Barred Rail	✓	
28	*Hypsipetes philippinus* (Forster, 1795)	Philippine bulbul	✓	✓
29	*Loriculus philippensis* (Müller, 1776)	Colasisi	✓	✓
30	*Macropygia tenuirostris* (Bonaparte, 1854)	Philippine cuckoo-dove	✓	
31	*Megalurus palustris* (Horsfield, 1821)	Striated grassbird	✓	✓
32	*Megapodius cumingii* (Dillwyn, 1853)	Tabon Scrubfowl	✓	
33	*Merops philippinus* (Linnaeus, 1767)	Blue-tailed bee-eater	✓	✓
34	*Motacilla cinerea* (Tunstall, 1771)	Grey Wagtail		✓
35	*Muscicapa griseisticta* (Swinhoe, 1861)	Grey-streaked flycatcher		✓
36	*Oriolus chinensis* (Linnaeus, 1766)	Black-naped oriole	✓	✓
37	*Passer montanus* (Linnaeus, 1758)	Eurasian tree sparrow	✓	✓
38	*Phapitreron leucotis* (Temminck, 1823)	White-eared brown dove	✓	✓
39	*Picoides maculatus* (Scopoli, 1786)	Philippine pygmy woodpecker		✓
40	*Pitta sordida (Müller, 1776)*	Hooded Pitta		✓
41	*Prioniturus discurus* (Vieillot, 1822)	Blue-crowned racquet-tail	✓	
42	*Psilopogon haemacephalus* (Müller, 1776)	Coppersmith barbet	✓	✓
43	*Pycnonotus goiavier* (Scopoli, 1786)	Yellow-vented bulbul	✓	✓
44	*Rhipidura nigritorquis* (Vigors, 1831)	Philippine pied fantail	✓	✓
45	*Sarcops calvus* (Linnaeus, 1766)	Coleto	✓	✓
46	*Saxicola caprata* (Linnaeus, 1766)	Pied bushchat	✓	✓
47	*Spilopelia chinensis* (Scopoli, 1786)	Spotted dove	✓	
48	*Spilornis cheela (Latham, 1790)*	Crested serpent eagle		✓
49	*Tanygnathus lucionensis (Linnaeus, 1766)*	Blue-naped parrot	✓	
50	*Todiramphus chloris* (Boddaert, 1783)	White-collared kingfisher		✓
51	*Zosterops everetti* (Tweeddale, 1878)	Everett's White-eye		✓
Mammals				
52	*Macaca fascicularis* (Raffles, 1821)	Long-tailed macaque	✓	✓
53	*Cynocephalus volans* (Linnaeus, 1758)	Philippine flying lemur	✓	✓
54	*Paradoxurus hermaphroditus* (Pallas, 1777)	Palm Civet		✓
55	*Ptenochirus* sp.	Fruit Bat	✓	✓
56	*Pteropus* sp.	Flying fox		✓
57	*Rattus* sp.	Philippine common field rat	✓	✓

No.	Scientific Name	Common Name	2015	2021
58	*Sundasciurus philippinensis* (Waterhouse, 1839)	Philippine Tree Squirrel	√	
59	*Sus philippensis* (Nehring, 1886)	Philippine warty pig	√	√
Reptiles				
60	*Malayopython reticulatus* (Schneider, 1801)	Reticulated phyton	√	√
61	*Chrysopelea paradisi* (H. Boie in F. Boie, 1827)	Paradise Tree Snake	√	
62	*Dendrelaphis caudolineatus* (Gray, 1834)	Striped Bronzeback snake	√	√
63	*Draco volans* (Linnaeus, 1758)	Common Flying Dragon	√	√
64	*Hydrosaurus pustulatus* (Eschscholtz, 1829)	Philippine sailfin lizard	√	
65	*Lamprolepis smaragdina* (Lesson, 1829)	Emerald skink	√	√
66	*Trimeresurus flavomaculatus* (Gray, 1842)	Philippine Pit viper		√
67	*Varanus marmoratus* (Wiegmann, 1834)	Monitor Lizard	√	√
Amphibians				
68	*Limnonectes magnus* (Stejneger, 1909)	Giant Philippine Frog		√
69	*Polypedates leucomystax* (Gravenhorst, 1829)	Common Tree Frog	√	√
70	*Rhinella marina* (Linnaeus, 1758)	Cane Toad	√	√
71	*Rana sp.*	Forest Tree Frog	√	
Total Number of Species			**51**	**52**

2.1.4.2.2 Conservation Status

Notable faunal species that were noted include those that are endemic or has a limited range of occurrence, as well as threatened species classified under the IUCN and the Department of Environment and Natural Resources Administrative Order (DAO 2019-09). **Table 2.1.21** shows the number of faunal species per faunal group belonging to the said categories.

Endemicity value is still high in the area more particularly for transects 2, 4 and 5. The said areas have a relatively different wildlife species due to the type of vegetation which ranges from closed canopy forest to open forest and brushland. In general, the population status of most of the identified species ranges from common to uncommon. Noteworthy bird species are those that are endemic to Mindanao or the Mindanao Faunal Region which include: Philippine dwarf-kingfisher (*Ceyx mindanensis*), Everett's white-eye (*Zosterops everetti*) and Blue-crowned racquet-tail (*Prioniturus discurus*). An amphibian was also noted to be endemic in Mindanao which is the Mindanao fanged frog (*Limnonectes magnus*).

Faunal species with threatened status under the IUCN classification were also noted in the site. Vulnerable species or species under high risk of endangerment include: Philippine dwarf kingfisher (*Ceyx mindanensis*), Long-tailed macaque (*Macaca fascicularis*), Philippine warty pig (*Sus philippensis*) and Philippine sailfin lizard (*Hydrosaurus pustulatus*). There are also two (2) species which are classified as Near-threatened: Blue-naped parrot (*Tanygnathus lucionensis*) and the Mindanao fanged frog (*Limnonectes magnus*). These species are identified to likely become endangered in the near future (IUCN, 2016).

Under the DENR DAO 2019-09, Critically Endangered species are those facing extremely high risk of extinction in the wild in the near future. Among the species identified in the site that are critically endangered are: Philippine hanging parrot (Loriculus philippensis) and Blue-naped parrot (Tanygnathus lucionensis) due to trapping from domestic and international trade (ADB, 2019). Vulnerable species are those that are likely to be endangered due to threats from adverse factors. The Philippine dwarf kingfisher (*Ceyx mindanensis*) and Palm civet (*Paradoxurus hermaphroditus*) are classified as Vulnerable. Under the DAO, there are also Other Threatened Species which are under threat from collection, predation, destruction of habitats or other similar causes. These species include: Brahminy kite (*Haliastur indus*), Blue-crowned racquet-tail (*Prioniturus discurus*), Reticulated phyton (*Malayopython reticulatus*), Striped bronze-back snake (*Dendrelaphis caudolineatus*) and Philippine pit viper (*Trimeresurus flavomaculatus*).

There are also several species that were listed by the Convention on International Trade in Endangered Species (CITES) as Appendix II. Species belonging in this category are identified to be 'not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival. Among these species are: Crested serpent wagle, Brahminy kite, White-bellied sea-eagle, Philippine hanging parrot, Blue-crowned racquet-tail, Long-tailed macaque, Reticulated phyton and Monitor lizard.

Table 2.1.20: Summary of the Number of Threatened Fauna Species

Faunal group	Endemic	IUCN Status		DAO 2019-09		
		Vulnerable	Near Threatened	Critically Endangered	Vulnerable	Other Threatened species
Birds	14	1	1	2	1	2
Mammals	4	2	-	-	1	-
Reptiles	3	1	-	-	-	3
Amphibians	1	-	1	-	-	-
TOTAL	**22**	**4**	**2**	**2**	**2**	**5**

2.1.4.2.3 Bird Species

A total of 51 species from 26 bird families were observed during the assessments. For birds, families with the greatest number of species are: Columbidae (doves and pigeons), Accipitridae (hawks and eagles) and Alcedinidae (kingfishers). Other bird families with three (3) species each include: Ardeidae (egrets and herons), Cuculidae (cuckoos and coucals), Dicaeidae (flowerpeckers) and Psittacidae (true parrots). The summary of the number of bird species per family is illustrated in **Figure 2.1.34**.

In terms of biogeographical distribution, about 69% are resident species, meaning, they occur in the Philippines as well as in other parts of the world. (**Figure 2.1.35**). A significant portion of the observed bird species (27%) are endemic or can only be found in the Philippines. Interestingly, about 4% were categorized as migratory species which include: Grey Wagtail (*Motacilla cinerea* and striated heron (*Butorides striata*) which is known to have migrant and resident populations in the Philippines (Kennedy et al., 2000).

In terms of feeding guild, majority of the observed species are insectivores (50%) which primarily feed on insects, spiders and other invertebrates (Figure 3). Insectivorous species are worth noting because aside from their potential to control pests, they are sensitive to habitat fragmentation because of their limited dispersal capabilities across fragmented landscapes (Benayas et al., 2017; Sekercioglu et al., 2001). Frugivores (16%) are important pollinators which may signify chances for seed dispersal of about 70-90% of rainforest tree species especially of native species (Moran et al. 2008). Also occurring at the sampling sites are Carnivores (8%) and Nectarivores (8%), Granivore or seed and grain consumers (6%), Piscivores or fish and invertebrate feeders (6%) and Omnivores (6%). According to studies, birds are said to be good indicators of habitat quality because they respond to habitat functions and there are species which are sensitive to habitat conditions (BirdLife International, 2013).

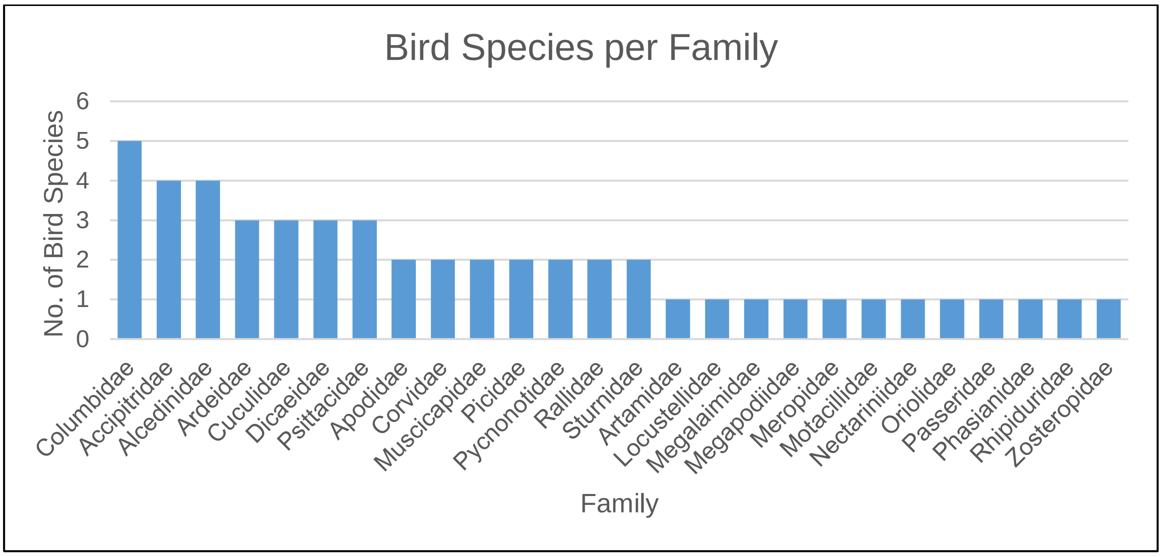


Figure 2.1.34: Number of Observed Bird Species per Family

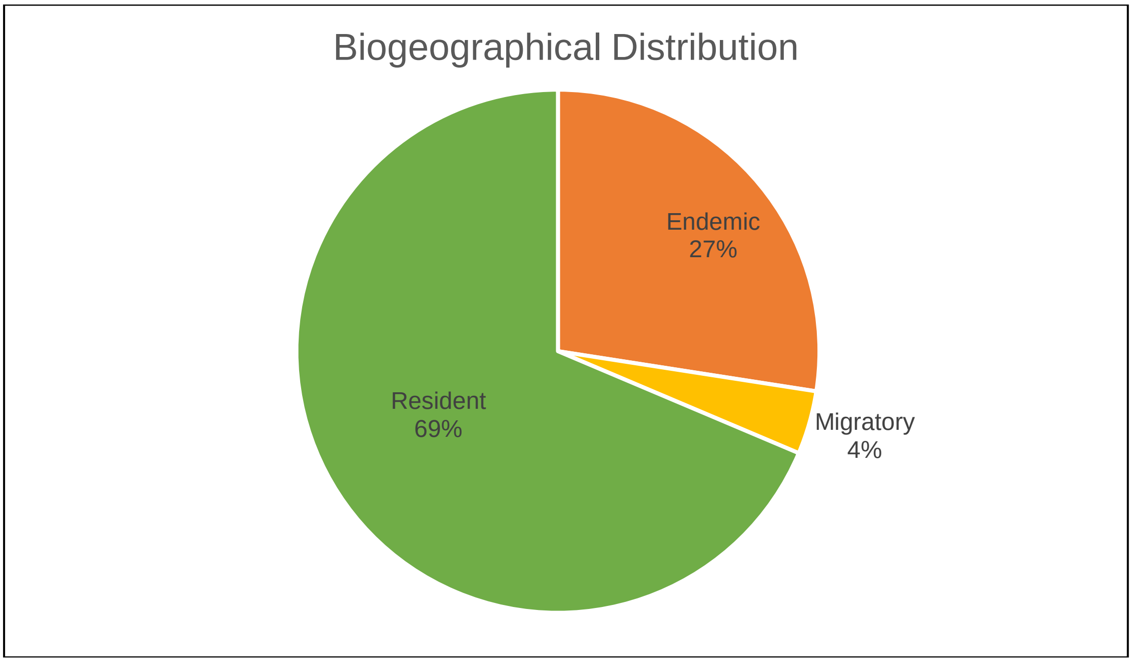


Figure 2.1.35: Percentage of Bird Species in terms of Biogeographical Distribution

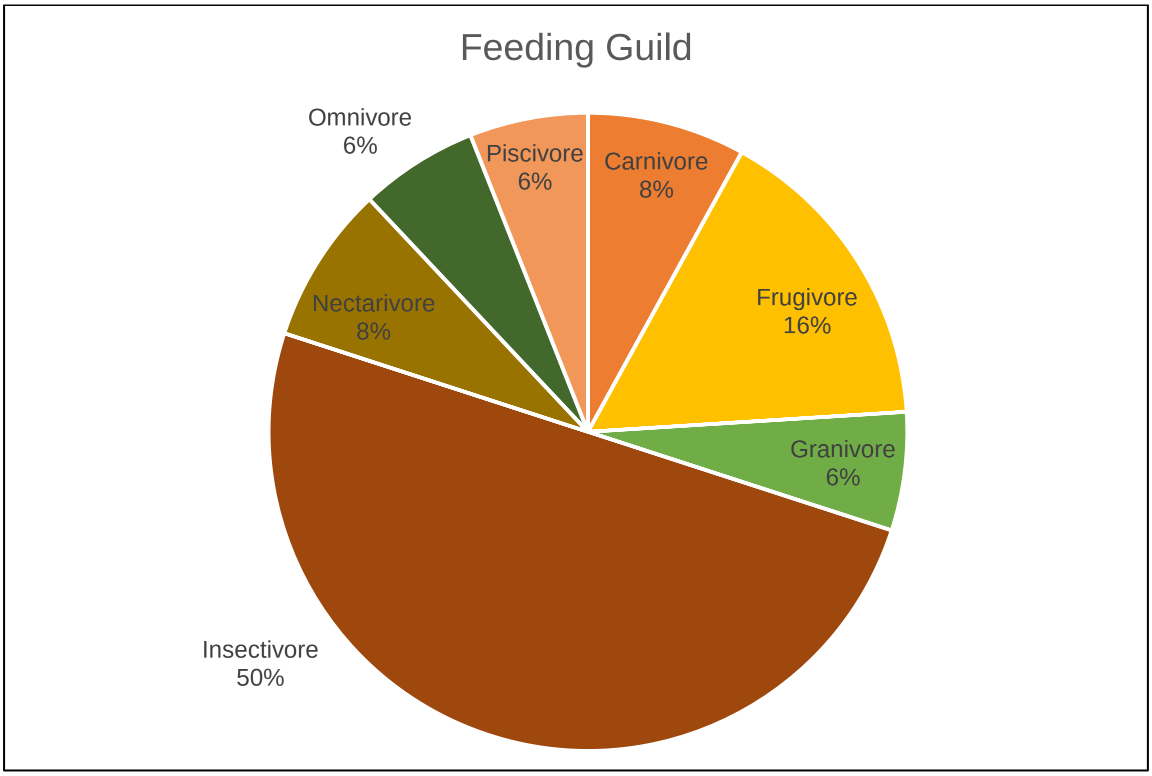


Figure 2.1.36: Percentage of Bird Species in Terms of Feeding Guild

Biodiversity indices were computed for birds in the site which include: Dominance, Shannon-Weiner Index, Simpson's Index and Evenness. The computed value for Shannon-Weiner was 2.539 which corresponds to moderate based Fernando's Biodiversity Scale for interpreting biodiversity indices (**Table 2.1.22**). Using the same scale, Evenness was computed at 0.5756 which indicates High value. Generally diverse forests are said to provide structural complexity to support a variety of bird species niche. Simpson's Index with a calculated value of 0.8713 is found to be low due to its nearness to the value of 1. Simpson's Index accounts for the proportion of species in the sample/site.

The complete list of observed bird species with their corresponding status, distribution, location in the blocks and transects are shown in **Table 2.1.23**. Some of the documented bird species within the site for verification and identification purposes are illustrated in **Plate 2.1.12**.

Table 2.1.21: Computed Biodiversity Index of Birds in the Survey Stations

Biodiversity Index	Formula	Value	Relative Value*
Dominance	D	0.1287	-
Shannon	H	2.539	Moderate
Evenness	e^H/S	0.5756	High
Simpson	1-D	0.8713	-
**Based on Fernando's Biodiversity Scale for interpreting diversity indices*			

Table 2.1.22: Bird Species Observed and their Corresponding Distribution, Feeding Guild and Conservation Status

No.	Family	Scientific Name	Common Name	Distribution	IUCN Status	CITES	DAO	Feeding Habit
1	Accipitridae	*Spilornis cheela (Latham, 1790)*	Crested serpent eagle	R	LC	App II		Car
2	Accipitridae	*Haliastur indus* (Boddaert, 1783)	Brahminy Kite	R	LC	App. II	OTS	Car
3	Accipitridae	*Haliaeetus leucogaster (Gmelin, 1788)*	White-bellied sea-eagle	R	LC	App II	-	Car
4	Accipitridae	*Circus melanoleucos* (Pennant, 1769)	Pied Harrier	R	LC	-	-	Car
5	Alcedinidae	*Todiramphus chloris* (Boddaert, 1783)	White-collared kingfisher	R	LC	-	-	Pis
6	Alcedinidae	*Ceyx lepidus (Temminck, 1836)*	Variable dwarf-kingfisher	R	LC	-	-	Ins
7	Alcedinidae	*Ceyx mindanensis (Steere, 1890)*	Philippine dwarf-kingfisher	E	Vul	-	Vul	Ins
8	Alcedinidae	*Halcyon gularis* (Kuhl, 1820)	White-throated Kingfisher	E	LC	-	-	Ins
9	Apodidae	*Collocalia troglodytes* (Gray, 1845)	Pygmy swiftlet	R	LC	-	-	Ins
10	Apodidae	*Collocalia esculenta* (Linnaeus, 1758)	Glossy Swiftlet	R	LC	-	-	Ins
11	Ardeidae	*Butorides striata* (Linnaeus, 1758)	Striated Heron	RM	LC	-	-	Pis
12	Ardeidae	Egretta garzetta (Linnaeus, 1766)	Little egret	R	LC	-	-	Pis
13	Ardeidae	*Ardea Ibis* (Linnaeus, 1758)	Cattle egret	R	LC	-	-	Ins
14	Artamidae	*Artamus leucoryn* (Linnaeus, 1771)	White-breasted woodswallow	R	LC	-	-	Ins
15	Columbidae	*Phapitreron leucotis* (Temminck, 1823)	White-eared brown dove	E	LC	-	-	Fru
16	Columbidae	Macropygia tenuirostris (Bonaparte, 1854)	Philippine cuckoo-dove	E	LC	-	-	Fru
17	Columbidae	*Spilopelia chinensis* (Scopoli, 1786)	Spotted dove	R	LC	-	-	Gran
18	Columbidae	*Geopelia striata* (Linnaeus, 1766)	Zebra dove	R	LC	-	-	Gran
19	Columbidae	*Chalcophaps indica* (Linnaeus, 1758)	Emerald Dove	R	LC	-	-	Fru
20	Corvidae	*Corvus Macrorhynchos* (Wagler, 1827)	Large-billed crow	R	LC	-	-	Omn
21	Corvidae	*Corvus enca (Horsfield, 1822)*	Slender-billed crow	R	LC	-	-	Omn
22	Cuculidae	*Cacomantis merulinus* (Scopoli, 1786)	Plaintive Cuckoo	R	LC	-	-	Ins
23	Cuculidae	*Centropus bengalensis* (Gmelin, 1788)	Lesser coucal	R	LC	-	-	Ins
24	Cuculidae	*Centropus viridis (Scopoli, 1786)*	Philippine coucal	E	LC	-	-	Ins
25	Dicaeidae	*Dicaeum australe* (Hermann, 1783)	Red keeled flowerpecker	E	LC	-	-	Nec
26	Dicaeidae	*Dicaeum bicolor (Bourns & Worcester, 1894)*	Bicolored flowerpecker	E	LC	-	-	Nec
27	Dicaeidae	*Dicaeum trigonostigma* (Scopoli, 1786)	Orange-bellied Flowerpecker	R	LC	-	-	Nec
28	Locustellidae	*Megalurus palustris* (Horsfield, 1821)	Striated grassbird	R	LC	-	-	-
29	Megalaimidae	*Psilopogon haemacephalus* (Müller, 1776)	Coppersmith barbet	R	LC	-	-	Fru
30	Megapodiidae	Megapodius cumingii (Dillwyn, 1853)	Tabon Scrubfowl	R	LC	-	-	Ins
31	Meropidae	*Merops philippinus* (Linnaeus, 1767)	Blue-tailed bee-eater	R	LC	-	-	Ins
32	Motacillidae	*Motacilla cinerea* (Tunstall, 1771)	Grey Wagtail	M	LC	-	-	Ins
33	Muscicapidae	*Muscicapa griseisticta* (Swinhoe, 1861)	Grey-streaked flycatcher	R	LC	-	-	Ins
34	Muscicapidae	*Saxicola caprata* (Linnaeus, 1766)	Pied bushchat	R	LC	-	-	Ins
35	Nectariniidae	*Cinnyris jugularis* (Linnaeus, 1766)	Olive-backed sunbird	R	LC	-	-	Nec
36	Oriolidae	*Oriolus chinensis* (Linnaeus, 1766)	Black-naped oriole	R	LC	-	-	Ins

No.	Family	Scientific Name	Common Name	Distribution	IUCN Status	CITES	DAO	Feeding Habit
37	Passeridae	*Passer montanus* (Linnaeus, 1758)	Eurasian tree sparrow	R	LC	-	-	Gran
38	Phasianidae	*Gallus gallus* (Linnaeus, 1758)	Red Jungle Fowl	R	LC	-	-	Ins
39	Picidae	*Chrysocolaptes guttacristatus* (Tickell, 1833)	Greater flameback	R	LC	-	-	Ins
40	Picidae	*Picoides maculatus* (Scopoli, 1786)	Philippine pygmy woodpecker	R	LC	-	-	Ins
41	Psittacidae	*Loriculus philippensis* (Müller, 1776)	Colasisi	E	LC	App II	CE	Fru
42	Psittacidae	*Tanygnathus lucionensis (Linnaeus, 1766)*	Blue-naped parrot	E	NT	-	CE	Fru
43	Psittacidae	Prioniturus discurus (Vieillot, 1822)	Blue-crowned racquet-tail	E	LC	App II	OTS	Fru
44	Pycnonotidae	*Hypsipetes philippinus* (Forster, 1795)	Philippine bulbul	E	LC	-	-	Fru
45	Pycnonotidae	*Pycnonotus goiavier* (Scopoli, 1786)	Yellow-vented bulbul	R	LC	-	-	Ins
46	Rallidae	*Pitta sordida (Müller, 1776)*	Hooded Pitta	R	LC	-	-	Ins
47	Rallidae	Hypotaenidia torquata (Linnaeus, 1766)	Barred Rail	R	LC	-	-	Ins
48	Rhipiduridae	*Rhipidura nigritorquis* (Vigors, 1831)	Philippine pied fantail	E	LC	-	-	Ins
49	Sturnidae	*Aplonis panayensis (Scopoli, 1783)*	Asian glossy starling	E	LC	-	-	Ins
50	Sturnidae	*Sarcops calvus* (Linnaeus, 1766)	Coleto	E	LC	-	-	Omn
51	Zosteropidae	*Zosterops everetti* (Tweeddale, 1878)	Everett's White-eye	R	LC	-	-	Ins

Note: E=Endemic; R=Resident
LC=Least Concern; EN=Endangered; CE=Critically Endangered; OTS=Other Threatened Species
Fru=Frugivore; Car=Carnivore; Pis=Piscivore; Ins=Insectivore; Gran=Granivore; Omn=Omnivore

Note: a.) Everett's white-eye; b.) Olive-backed sunbird-female; c.) Olive-backed sunbird-male; d.) Grey-streaked flycatcher; e.) White-breasted woodswallow and f.) Pied bushchat

Plate 2.1.12: Observed Bird Species in the Survey Stations

2.1.4.2.4 Mammalian species

A total of eight (8) species belonging to eight (8) genus and seven (7) families of mammals (volant and non-volant) were observed within the site during the assessment periods (**Table 2.1.24**). Among the species of volant mammals that were observed/noted in the area are fruit bats (*Ptenochirus* sp.) and the flying foxes (*Pteropus* sp.) which were noted to be sometimes hunted as food according to locals. Both bat species belong to the Pteropodidae family which are dog faced bats with relatively larger eyes for vision compared to other bat families due to their inability to echolocate (Ingle and Heaney, 1992).

One of the species observed in the area with reports of hunting is the Philippine warty pig (*Sus philippensis*) which is also categorized as Vulnerable according to IUCN. During the assessment, presence of the Philippine warty pig is evidenced by foot tracks and signs of rummaging in soil/rocks and fallen leaves/twigs (**Plate 2.1.13**).

Several animal traps were also observed in the site which is being used to capture warty pigs. According to locals, the said traps can also be used to trap reptilian species such as monitor lizards and even snakes. One trap is made up of sticks arranged in a circular manner surrounding a bait. More sticks are attached to its sides, where the animal will pass through until it is captured by a nylon string attached to one of the sticks (**Plate 2.1.14a**). Another type of trap that was observed in the area is a moving trap hidden underground and attached to a small tree branch through a string (**Plate 2.1.14b**).

Non-volant mammals were also observed and noted to occur in the area. An Asian house rat (*Rattus cf. tanezumi*) was caught in a live trap along the secondary forest area. Other mammals noted from ethnobiological accounts with threatened status are: Long-tailed macaque (CITES: Appendix II; DENR DAO 2019-09: Other threatened species) and Palm civet (IUCN: Vulnerable). The latter is also listed as Appendix III in CITES in which trade have been officially regulated.

Plate 2.1.13: Foot Track (a) and Rummaging (b) of a Warty Pig Observed in the Area

Plate 2.1.14: Types of traps observed in the area: a.) sticks arranged circular manner and b.) hidden moving trap attached to a string

2.1.4.2.5 Herpetofauna

A total of 12 species of herpetofauna were observed within the site during the assessment periods, specifically, eight (8) species of reptiles and four (4) species of amphibians (**Table 2.1.24**). The species were listed from opportunistic sampling and ethnobiological accounts.

Noteworthy threatened herpetofauna species in the site are: Philippine Sailfin lizard (IUCN: Vulnerable), Reticulated python (CITES: Appendix II), Monitor lizard (CITES: Appendix II) and the Mindanao fanged frog (IUCN: Near-threatened). According to Tanalgo (2017), other species which are noted to be hunted in the Philippines are: P. *reticulatus* and Monitor lizard (Varanus sp.) which were noted to occur in the assessment site.

Anuran (frog) species belonging to four (4) families were observed to commonly occur in the area, such as the Cane toad (*Rhinella marina*), a known invasive and pest species which prefers wet habitats overlapping with native species (Mayer et al., 2017). These observed species are known to occur in a variety of habitats including highly disturbed areas. Another common frog species found is the Common tree frog (*Polypedates leucomystax*) which according to Brown et al., (2010), recently expanded in the Philippines and Indonesia due to the widespread conversion of forests into agricultural-use land. The species is also frequently found in trans-island agricultural shipments.

Table 2.1.23. Species of Mammals, Reptiles and Amphibians with their Corresponding Distribution and Conservation Status

Family	Scientific Name	Common Name	Distribution	IUCN Status	CITES	DAO
Mammals						
Cercopithecidae	*Macaca fascicularis* (Raffles, 1821)	Long-tailed macaque	R	Vul	App II	
Suidae	*Sus philippensis* (Nehring, 1886)	Philippine warty pig	E	Vul	-	
Cynocephalidae	*Cynocephalus volans* (Linnaeus, 1758)	Philippine flying lemur	E	LC	-	
Viverridae	*Paradoxurus hermaphroditus* (Pallas, 1777)	Palm Civet	R	LC	App III	Vul
Muridae	Rattus sp.	Philippine common field rat	R	LC	-	
Sciuridae	*Sundasciurus philippinensis* (Waterhouse, 1839)	Philippine Tree Squirrel	E	LC	-	
Pteropodidae	*Pteropus* sp.	Flying fox	E	LC	-	
Pteropodidae	*Ptenochirus* sp.		E	LC	-	
Reptiles						
Pythonidae	*Malayopython reticulatus* (Schneider, 1801)	Reticulated phyton	R	LC	App II	OTS
Varanidae	*Varanus marmoratus* (Wiegmann, 1834)	Monitor Lizard	E	LC	App II	
Agamidae	*Draco volans* (Linnaeus, 1758)	Common Flying Dragon	R	LC	-	
Scincidae	*Lamprolepis smaragdina* (Lesson, 1829)	Emerald skink	R	LC	-	
Agamidae	*Hydrosaurus pustulatus* (Eschscholtz, 1829)	Philippine sailfin lizard	E	Vul	-	OTS
Colubridae	*Dendrelaphis caudolineatus* (Gray, 1834)	Striped Bronzeback snake	R	LC	-	
Colubridae	*Chrysopelea paradisi* (H. Boie in F. Boie, 1827)	Paradise Tree Snake	R	LC	-	
Viperidae	*Trimeresurus flavomaculatus* (Gray, 1842)	Philippine Pit Viper	E	LC	-	OTS
Amphibians						
Dicroglossidae	*Limnonectes magnus* (Stejneger, 1909)	Giant Philippine Frog	E	NT	-	
Rhacophoridae	*Polypedates leucomystax* (Gravenhorst, 1829)	Common Tree Frog	R	LC	-	
Bufonidae	*Rhinella marina* (Linnaeus, 1758)	Cane Toad	R	LC	-	
Ranidae	*Rana sp.*	Forest Tree Frog	R	LC	-	
Note: **LC=Least Concern; EN=Endangered; CE=Critically Endangered; OTS=Other Threatened Species**						

2.1.4.3 Vegetation Removal and Loss of Habitat

Different stages of mining posed different threats to local floral assemblage of a site. One of the most prominent effects is the clearance of the forest to give way for the construction of mine facilities and for the actual extraction phase of the project. As early as the exploration and and initial investigation of the site, there are minimal effects to the flora of the site. This includes clearing of patches of plants to give way for ocular investigations.

The most abrupt effect of the mining project to the site forest will be during the construction and operations phase wherein clearance of the forest is expected. Clearance is usually deemed necessary in the construction phase since road and facilities constructions are expected to be completed on this phase of the mining project. Extensive plan on the clearance of the forest is essential since it is vital to prevent unnecessary damages to the forest.

2.1.4.4 Threat to Existence and/or Loss of Important Local Species and to Abundance, Frequency and Distribution of Important Species

The areas to be mined are expected to be cleared off vegetation. It is inevitable that tree species with high IVs, endemic species and threatened species will be affected by the operations. The clearance of vegetation affects also the associated faunal groups on the terrestrial flora. Nesting and feeding grounds of animals are expected to be cleared hence habitat of these organisms will be fragmented.

During the operations phase, more clearance of the forest is expected since parcels will be activated for extraction of the ores. Other facilities such as settling ponds will be operational and will consume significant area of land. Since damages to the local ecosystem are expected, maintenance of buffer zones in the circumference of the damaged area is needed. These buffer zones must be designed to neutralize the effects of the mining activities, thus preventing the effects to reach other parts of the forests. One of the major example of these are riparian buffer ones. These buffer zones are designed to prevent the damages of the mining activities to reach the streams and rivers. Usually, a layer of riparian vegetation is left untouched to serve as the buffer zone of the area.

Plants that are already listed on the list of threatened species must be taken into prime importance for the conservation efforts of the mining sites. Determined species must be the focus of the nursery operations. For example, batikuling (*Litsea leytensis)* found in Stations 4 and 5 are needed to be propagated and needs to be planted in the buffer zone. Across the phase of rehabilitation, endemic and endangered tree species must be planted when soil conditions are suitable for replanting.

Progressive rehabilitation of the damaged parcels must commence once a parcel is declared mined-out. Conservation of the local biodiversity must be incorporated on the progressive rehabilitation strategies. This can be done by using a mixture of known reforestation trees such as the leguminous plants that are capable of nitrogen-fixing i.e. Mangium (*Acacia mangium)* and Auri (*A. auriculiformis*) with other indigenous trees that were determined to be part of the original landscape of the area. During the assessment, dominance of agoho (*C. equisitifolia*) was observed. This tree species is then also recommended to be planted since it can thrive on the area. Numerous mining rehabilitation schemes also uses agoho as one of the pioneer species to be planted during the rehabilitation phase.

Re-vegetation of most mining areas involves different considerations due to the changes in the physical and chemical conditions brought by the mining operations. The land topography, for example is drastically changed by mining operations. The necessary flattening and alteration of the original slope for the mines' access roads, conveyor system, settling ponds, etc. requires different conditions for the selection of species for rehabilitation.

Aside from trees, other smaller plants such as shrubs, herbs, ferns and grasses can help in reforesting the area. As discussed on the floral composition of the mining sites, different understory species can be found on the area. This will also ensure diversity of species found on the area. From the ecological succession model, grasses and smaller plants are first plants to spring naturally in a damaged area. Shrubs such as *M. malabatrichium* that are naturally dominant in the area, as supported by this terrestrial ecology survey is highly recommended to be planted along ferns and grasses that can stabilize the microclimate of the mined-out area prior to planting of larger tree species.

The elevation of the area varies from steep to rolling, as observed visually during the assessment. It is expected that the operations will bring drastic alteration of the slope. Combined with the loss of vegetation, slope alteration may bring massive siltation to the surrounding waters. One step to prevent physical erosion of steep slopes is by planting grass species. Introduction of the species that hastens the recovery of the forest dynamics such as nutrient cycle provided resultant rehabilitation of the site, however, local species present in the areas must be considered to be planted as well. Grasses like vetiver (*Chrysopogon zizanioides*) are often used in mining rehabilitation since it can easily grow in barren lands and even in slopes. According to the Research Compendium on Mining and Volcanic Area, vetiver grass is often used since it has stiff and erect stems which can stand up to relatively deep water flow (0.6-0.8m). It also forms hedges when individual plants form a cluster. These hedges are good filters of soil and water since they can reduce water's flow velocity and diverting surface run-off.

2.1.4.5 Hindrance to Wildlife Access

Faunal communities thriving in the forest will lose the vegetative cover where they live. To minimize further damage to animals, all operations must be careful in possible physical damages and death to animals living in those areas to be cleared. Further, nurseries to be established can also serve as animal center wherein rescued animals such as young birds and mammals can be reared prior to its release to the surrounding forest.

Environmental protection and enhancement plan of the mining operations must also include massive Information and Education Campaign (IEC) regarding biodiversity conservation. Employing locals in for environmental activities such as mine reforestation is highly recommended to include the community in the reforestation of the forest that will be disturbed.

2.2 WATER

2.2.1 Hydrology/Hydrogeology

2.2.1.1 Drainage Morphology

The project site is located in an area where there are nearby watersheds.

Benoni River is one of the two (2) large river systems draining into Carrascal River, the major river in the municipality. The name Benoni River is adopted here to represent the entire stretch of the channel that changes names as it passes through the different barangays from its headwaters in Pantukan to the downstream reaches in Bacolod. The name of the river changes from Pantukan River to Babuyan River to Panikian River and lastly, to Benoni River depending on the location of a segment.

The watershed has a tapering semi-elongated shape, i.e., broad at the headwaters and narrows towards the mouth. It is underlain by different types of lithology including ultramafic rocks, spilites or metabasalts and alluvium. The ultramafics and spilites are heavily fractured that provide avenues for the percolation of rainwater and for storage and transmission of groundwater. Soil is largely clay and described by BSWM as Kabatohan Clay Loam, San Miguel Silt Loam and undifferentiated Mountain Soil as described earlier. Rainfall is captured by soils capture via infiltration that eventually percolates into the aquifer as groundwater.

The 7,280 ha watershed is largely covered by moderately to highly dense forest vegetation in the upper section and by agricultural crops in the lower section predominantly rice. It is characterized by rugged topography of high relief in the upper section, a rolling topography of low relief in the midslopes and a flat topography in the alluvial plains.

Drainage system is described as dendritic wherein stream have no preferred orientation while streams are basically in the 4thdegree order only suggesting that drainage system is still in the young stage of development. The main channel has a length of about28.5 km with elevation difference of1,095 meters from the tip of the headwaters (1,100 m) to its confluence with Alamio River in Bacolod (5m). Discharge at the upper reaches (Pantukan) of the river was measured at 21.13 m3/s and increases as the river passes through Panikian at 27.38 m3/s. This means that the Pantukan segment of the river is contributing 77% of it discharge at this point. This river is perennial although the discharge is substantially reduced during the dry seasons.

Watershed of Marga River

The steeply sloping watershed is almost circular in shape. It is largely underlain by ultramafic rocks within the circle and by clastics mostly sandstones at the mid slopes and alluvium at the lower reaches. The ultramafics are heavily fractured and provide avenues for the percolation of rainwater and for storage and transmission of groundwater. Soil is largely clay and described by BSWM as Kabatohan Clay Loam as characterized earlier. This soil captures rainfall via infiltration, which subsequently percolates into the deeper section of fractured rocks.

The 1,480-hectare watershed is largely covered by moderately to highly dense forest vegetation in the upper section and by grasses and shrubs in the lower section. It is characterized by a rugged topography of high relief in the upper section, a rolling topography lower section, and a flat topography towards the mouth of the main channel.

Drainage system is described as centripetal wherein streams flow into one common direction, i.e., towards the center of the watershed. The streams are basically in the 4th degree order only suggesting that drainage system is still in the young stage of development. The main channel has a length of about 19.5 km with elevation difference of 945 meters from the tip of the headwaters (950 m) to its confluence with Adlay River (5m). Marga River is discharging at a rate of 5.8 m3/s. The flow is highly dynamic during the rainy season such that the configuration changes so abruptly in one storm event. This is however, an intermittent river that losses its water during the dry months of August to September.

Marga River is used as a bathing and washing area of the residents of Brgy. Adlay. Two (2) springs are recharged by this river all of which supply water to the community. One spring at the elevated section of the watershed was developed to supply water to the community and a big number of household are already enjoying house connection. Another spring is located at the abandoned channel of the river and it is discharging at a rate of 0.05 m3/s, during rainy season but almost dry up near the end of the dry season.

Watershed of Adlay River

Characterized by a gradually sloping topography at the center and a rugged terrain in its divide, the watershed is sparsely forested and a substantial portion is supposedly dedicated to agriculture but cultivation has already stopped. It is largely underlain by clastic and ultramafic rocks where the clastics occupy the lowland and the ultramafics underlain the mountain ranges. The ultramafics are heavily fractured and provide avenues for the percolation of rainwater and for storage and transmission of groundwater. Soil is largely clay and described by BSWM as Kabatohan Clay Loam as characterized in earlier section. This soil captures rainfall via infiltration which subsequently percolates into the deeper section of the fractured rocks.

The 1,380-hectare watershed is largely covered by grasses and patches of shrubs and trees. The lowlands are mostly covered by grasses while the highlands by forest trees of secondary growths. It is characterized by a rugged topography of high relief near the watershed divide, e gently sloping topography in the transition zone and a flat topography at the lowlands.

Drainage system is described as dendritic since there is no preferred orientation for the multiple streams. The streams are also in the 4th degree order suggesting that drainage system is still in the young stage of development. The main channel has a length of about 6.5 km with elevation difference of 400 m. This is an intermittent river that losses its water during long dry months. Adlay River is used for irrigation, bathing, washing and for the drinking water for livestock.

2.2.1.2 Stream Volumetric Flow

The three (3) drainage systems discussed earlier have no gauging stations and if we need to know the hydrographic characteristics of these systems, we will never be able to precisely determine the details. However, there are some available methods that may give an estimate for instance of the monthly flows by using the information obtained by a gauged system located near these drainage systems. In the case of the projects site, the nearest gauged drainage is the Carac-an River located in Brgy. Parang, Cantilan, Surigao del Sur and defined by geographic coordinates 9o 14' 23" north latitude and 125o 56' 10" east longitude.

The data obtain from this gauging station covers the period 1950 to 1970 (21 years) as presented in NWRB's Philippine Water Resources Summary Data (1980). Carac-an River has a watershed area of 240 km^2 or 24,000ha. Using the simple ratio and proportion formula where the areas and flows of the rivers are correlated, the mean monthly flows of the three (3) rivers were estimated as shown in **Table 2.2.1**.

$$\frac{DA1}{Q1} = \frac{DA2}{Q2}$$

where DA1 - Drainage Area of the gauged river system, *km²*
DA2 - Drainage Area of the ungauged river system, *km²*
Q1 - Mean Monthly Flow of the gauged river system, *m³/s*
Q2 - Mean Monthly Flow of the gauged river system, *m³/s*

Table 2.2.1: Mean Monthly Discharge of Carac-an River and Estimates of Benoni, Marga and Adlay Rivers

Month	Gauged Mean Monthly Q of Carac-an River (m^3/s)*	Estimated Mean Monthly Q of Benoni River (m^3/s)	Estimated Mean Monthly Q of Marga River (m^3/s)s	Estimated Mean Monthly Q of Adlay River (m^3/s)
Area (km^2)	**240.0**	**72.8**	**14.8**	**13.8**
January	111.42	33.80	6.87	6.41
February	86.57	26.26	5.34	4.98
March	70.70	21.45	4.36	4.07
April	32.26	9.79	1.99	1.85
May	28.38	8.61	1.75	1.63
June	24.15	7.33	1.49	1.39
July	23.45	7.11	1.45	1.35
August	13.06	3.96	0.81	0.75
September	12.31	3.73	0.76	0.71
October	11.86	3.60	0.73	0.68
November	19.86	6.02	1.22	1.14
December	84.76	25.71	5.23	4.87

*BRS DPWH, Philippine Water Resource Summary Data Volume I (1980)

In terms of volume, each of the rivers can deliver a considerable amount of water every month. In **Table 2.2.2**, a monthly production of surface water is presented for each of the rivers identified at the project site. In this table, all of the months are productive even during the dry season has left the some of the rivers empty particularly Marga River. This is the weak point of the ratio and proportion method wherein the principal river does not dry up throughout the year and therefore this will be reflected in the river being correlated. However, it could also be that half of the dry month has no rain and the other half has. This will be determined by a monthly water balance.

Table 2.2.2: Estimated Volume of Water that each of the Drainage System can Produce Monthly

Month	Gauged Monthly Q of Carac-an River (m^{3*})	Estimated Monthly Q of Benoni River (m^3)	Estimated Monthly Q of Marga River (m^3)	Estimated Monthly Q of Adlay River (m^3)
January	288,800,640.00	87,602,860.80	17,809,372.80	16,606,036.80
February	224,389,440.00	68,064,796.80	13,837,348.80	12,902,392.80
March	183,254,400.00	55,587,168.00	11,300,688.00	10,537,128.00
April	83,617,920.00	25,364,102.40	5,156,438.40	4,808,030.40
May	73,560,960.00	22,313,491.20	4,536,259.20	4,229,755.20
June	62,596,800.00	18,987,696.00	3,860,136.00	3,599,316.00
July	60,782,400.00	18,437,328.00	3,748,248.00	3,494,988.00
August	33,851,520.00	10,268,294.40	2,087,510.40	1,946,462.40
September	31,907,520.00	9,678,614.40	1,967,630.40	1,834,682.40
October	30,741,120.00	9,324,806.40	1,895,702.40	1,767,614.40
November	51,477,120.00	15,614,726.40	3,174,422.40	2,959,934.40
December	219,697,920.00	66,641,702.40	13,548,038.40	12,632,630.40

Water Balance Analysis was used to describe the flow of water in and out of a hydrological system. It is also referred to as hydrologic budget that quantifies the balance of water loss of gain in a drainage basin. Water balance can be applied to certain time period, in this case annually. The water balance for a yearly period is expressed in the following equation:

$$P = Q + Et + Gs$$

where P is the annual precipitation,
Q is the runoff depth,
Et is the evapotranspiration and
Gs the groundwater storage.
Units are expressed in millimeters (mm).

The rainfall data were obtained from the Surigao Airport Synoptic Station and assuming these also represents the climate in the project site, the values were substituted directly to the variable.

The annual evapo-transpiration value of 1,380 mm calculated by previous workers was adopted and distribution proportionately into the 12 months. It is understood that they used Blaney-Criddle method as presented below, utilizing the available temperature data from the climatic station in Surigao City.

$$ETo = p \cdot (0.46 \cdot Tmean + 8)$$

Where:
ETo is the reference evapotranspiration [mm day−1] (monthly)
Tmean is the mean daily temperature [°C] given as *Tmean = (Tmax + Tmin)/ 2*
p is the mean daily percentage of annual daytime hours.

The groundwater storage Gs, which is part of the rainfall that percolates deeper through fractured media is determined by the water balance equation and the results are presented in **Table 2.2.3.** The water balance analysis represents the crude approximation of the hydrologic regime of the mine area. The groundwater storage which represents 1.8% of the rainfall is the balance of rainfall that may seep or percolate into either the fractured or the weathered zones of the massive ultramafic rocks or thin lenses of unconsolidated sediments. These form springs and shallow aquifers in low lying areas which are tapped by the communities for domestic water. It must be emphasized that the Project area exhibits low potential groundwater with limited groundwater yields. Laterites are clay sediments, which are considered as poor aquifers. The bedrock is usually massive with groundwater limited to weathered or fractured zones.

Table 2.2.3: Groundwater Storage Calculated from Water Balance Computation at Different River Systems

Month	Precipitation	Groundwater Storage at Benoni River in mm	Groundwater Storage at Marga River in mm	Groundwater Storage at Benoni River in mm
January	609.40	339.00	339.00	339.00
February	446.40	246.54	246.54	246.54
March	326.00	177.35	177.35	177.35
April	219.10	124.69	124.69	124.69
May	139.60	76.63	76.63	76.63
June	142.10	79.71	79.71	79.71
July	171.10	98.00	98.00	98.00
August	133.90	78.60	78.60	78.60
September	171.00	101.95	101.95	101.95
October	240.70	145.47	145.47	145.47
November	467.30	283.56	283.56	283.56
December	585.20	333.54	333.54	333.54
Annual	3,651.80	2,085.04	2,085.04	2,085.04

2.2.1.3 Flood Peak and Volume

The same method was used in estimating flood peak values of ungauged rivers and this is the Basin – Factor Ratio Method. The approach is linearly proportioned to the basin size and peak flows with corresponding return period of the gauged rivers to the ungauged rivers with generally the same geology, rainfall pattern, basin shape, land use, among others. The historical annual peak flow of Carac-an River was subjected to Point – Flood Frequency Analysis using Extreme Gumbel Type I distribution. **Table 2.2.4** shows the projected peak flows in the locality of the project site.

Table 2.2.4: Peak Flows of Ungauged Rivers using Carac-an River as Basis

River Name/ Location	Drainage area, (km2)	Mean Annual Flood (MAF)	Return Period, yr			
			10	25	50	100
Carac-an River	240	1,250	1700	2150	2500	2700
Marga River	12.00	54.5	98	131	167	207
Adlay River	6.00	27	49	66	84	104
Benoni River	72.00	327	589	785	1000	1243

2.2.1.4 Debris Flow

This is rapid process wherein water-laden masses of soil and fragmented rock rush down mountainsides, funnel into stream channels, entrain objects in their paths, and form thick, muddy deposits on valley floors and alluvial fans. It is differentiated from mudflows through the size of materials in the fluid mix. The former has relatively finer loads such as sands, silts and clays while the later has larger ones that may include cobbles, boulders and even logs. The barangay proper is resting on an alluvial fan or accumulation zone. The fan appears to have been formed from highly dynamic flood flows or on extreme cases, debris flow along Marga River. The extensive presence of boulders and cobbles in the fan suggests such condition. Although the Marga River has already shifted its channel away from the built-up areas, a massive landslide occurring in its river system may choke the present channel or considerably raise the riverbed by sediment deposition somewhere in an elevation higher than the highest elevation of the barangay proper and shift the floodflow towards the barangay thereby inundating it. Worse is, if this is accompanied by a large amount of debris consisting of mud, rocks and plant remains, a more fatal process could take over. This has now transformed into debris flow and the sheer energy it carries can cause massive damage to properties and even significant loss of lives.

For debris flow to occur, the phenomenon must be preceded by torrential rains and punctuated by intense rainfall to move the earth materials along slopes and river channel. As already cited, this is a rapid process and may not allow a significant lead time to run for safety although a thunderous sound like an approaching train may be heard ahead of the actual flow. Thus, the barangay residents shall be aware of this to prevent loss of lives. It is therefore necessary for evacuation to be done in advance.

Surigao City has already experienced high intensity rainfall in the level of 566.24 mm on December 18-19, 2003. This was distributed throughout the day and spiked in the evening of December 18. **Table 2.2.5** shows the three hourly readings at the Surigao Airport Synoptic Station. For a better appreciation of these amounts, **Figure 2.2.1** shows the histogram of the three-hourly rainfall reading. Comparing the daily rainfall extremes to the month normals, the two values are almost the same (**Figure 2.2.2**). Between 5 and 11 PM, the intensity of rainfall was 40 mm/hr. Not as high as the intensity 61.4 mm/hr for Ty Ondoy in Manila (**Figures 2.2.3** and **2.2.4**) but substantial enough to cause extensive floods. Extreme rainfall event recorded at the Surigao City Synoptic Station peaking at 556.4 mm on December 18, 2003 and 564.7 mm on November 18, 1968.

This intensity is already dangerous if sustained and could also happen in Carrascal. In such event, debris can be induced. **Plate 2.2.1** shows images of debris flow that already happened in the country.

Table 2.2.5: Three-Hourly Distribution of the Most Extreme Rainfall Recorded at the Surigao City Synoptic Station on December 18-19, 2003

Time of Day	Amount in mm	Duration in hours
11:00 AM	24.0	3
02:00 PM	41.2	3
05:00 PM	89.8	3
08:00 PM	100.8	3
11:00 PM	126.2	3
02:00 AM	62.2	3
05:00 AM	39.2	3
08:00 AM	53.0	3
Total	**566.24**	**24**

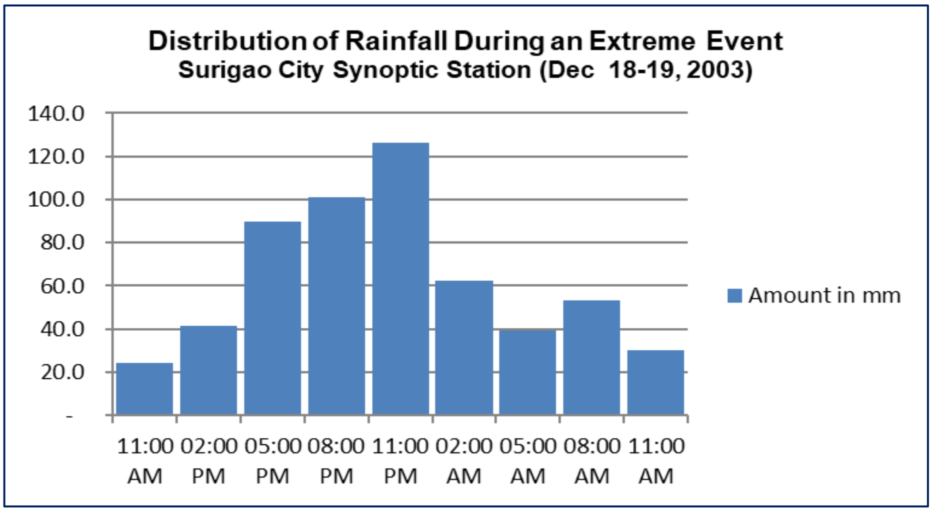


Figure 2.2.1: Distribution of Rainfall during an the Extreme Event for 24 hours

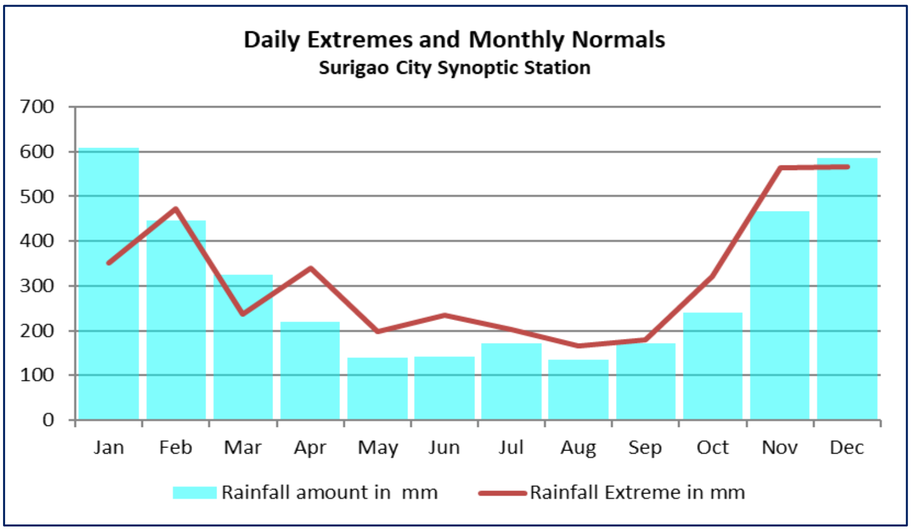


Figure 2.2.2: Extreme Rainfall Event Recorded at the Surigao City Synoptic Station

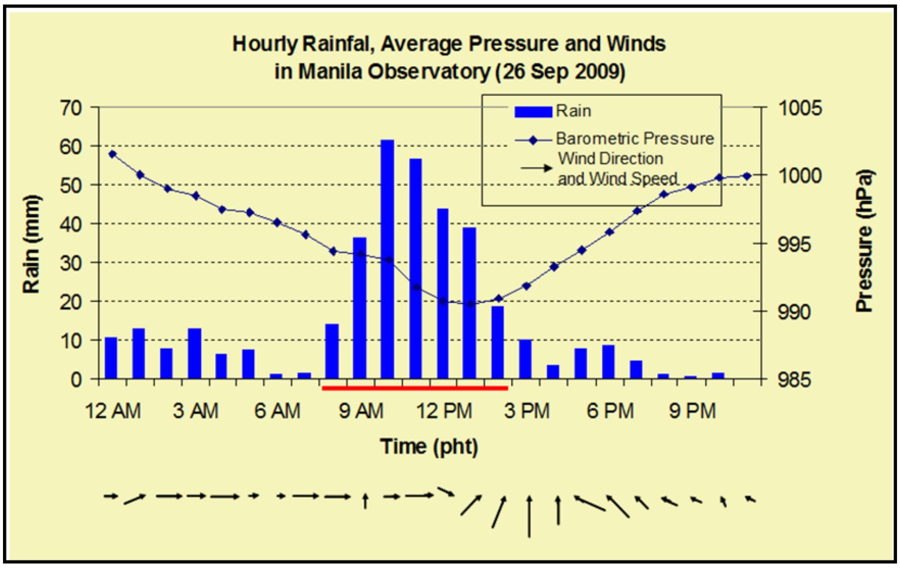


Figure 2.2.3: Rainfall intensity during Ty Ondoy (61.4mm/hr) in Metro Manila

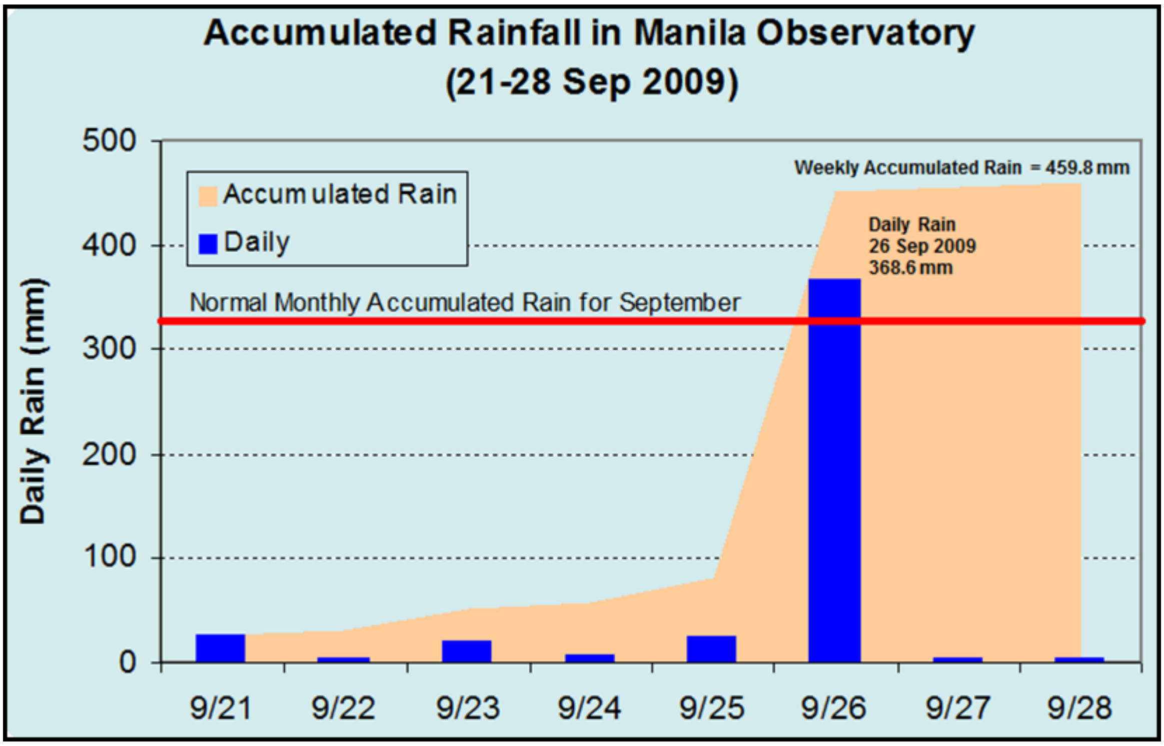


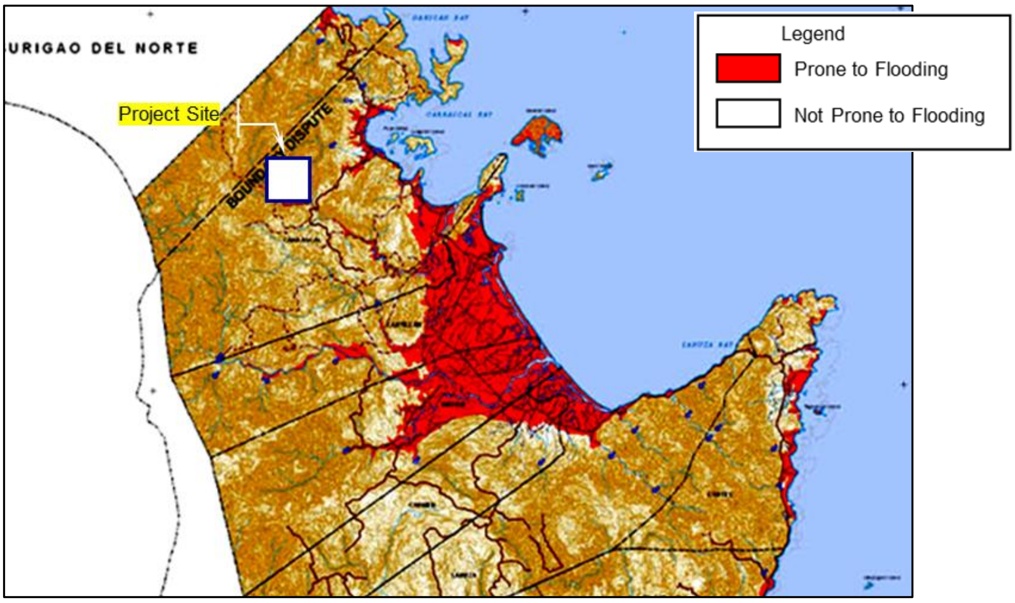
Figure 2.2.4: Day's rainfall (368.8 mm) during the Passage Ty Ondoy against a September normal (330.3mm)

Plate 2.2.1: Debris Flow in Dingalan, Aurora (l) and Infanta, Quezon (r)

2.2.1.5 Fluvial Flooding

Fluvial flooding a form of flash flood that is less potent than debris flow but highly dynamic as to create considerable devastation in the community. The same conditions as above are needed for the occurrence of such hazard and the same area will be affected. It will actually be a prelude to a debris flow should this phenomenon indeed happens.

Based on **Figure 2.2.5**, the project site is not susceptible to flooding. It suggests that the proposed project site is least likely to experience flood heights of 0.5 m or less and/or flood duration of less than one (1) day.



Source: READY Project Hazard Maps

Figure 2.2.5: Flood Hazard Map of Surigao del Sur showing the Project Site

2.2.1.6 Coastal Flooding

Inundation of coastal areas may be caused by storm surge during a passage of a super typhoon or by tsunami in an event that an offshore earthquake may be generated directly east of the barangay. Storm surge can occur at Carrascal Bay assuming a typhoon of the Pablo's or Yolanda's strength will landfall somewhere between Carrascal and Cantilan or farther south. The location of landfall is important since the generation of storm surge is at the right side of the eye of the typhoon. Carrascal Bay has shallow continental shelf which is favorable to the development of storm surge of considerable height, i.e., 3 m or greater. There is a small strait connected to Carrascal Bay and leading to Brgy. Adlay and this is foreseen as the avenue where a storm surge can pass through. A constriction posed by coral reefs between Puyo Island and a point in the mainland northeast of the Adlay can break the energy of incoming waves but this may not be enough to prevent inundation of the coastal areas of the barangay. The puroks that will feel the full brunt of the surge or tsunami will be Puroks 7, 8, 1 and 6 followed by Puroks 2, 3, 4 and 5 in that order.

During the approach of super typhoons which can also bring intense rainfall, these puroks should be vacated prior to landfall but with enough lead time for preparations and the residents be temporarily sheltered in elevated areas, i.e., 15 mamsl at least.

2.2.1.7 Hydrogeology

Based on the groundwater map prepared by NWRB (**Figure 2.2.6**) for Surigao del Norte, the project site is classified as difficult area which means that sourcing of water is not that easy because of the inherent impermeability of the underlying rock formation (**Figure 2.2.7**). The water supply in the area is indeed limited.

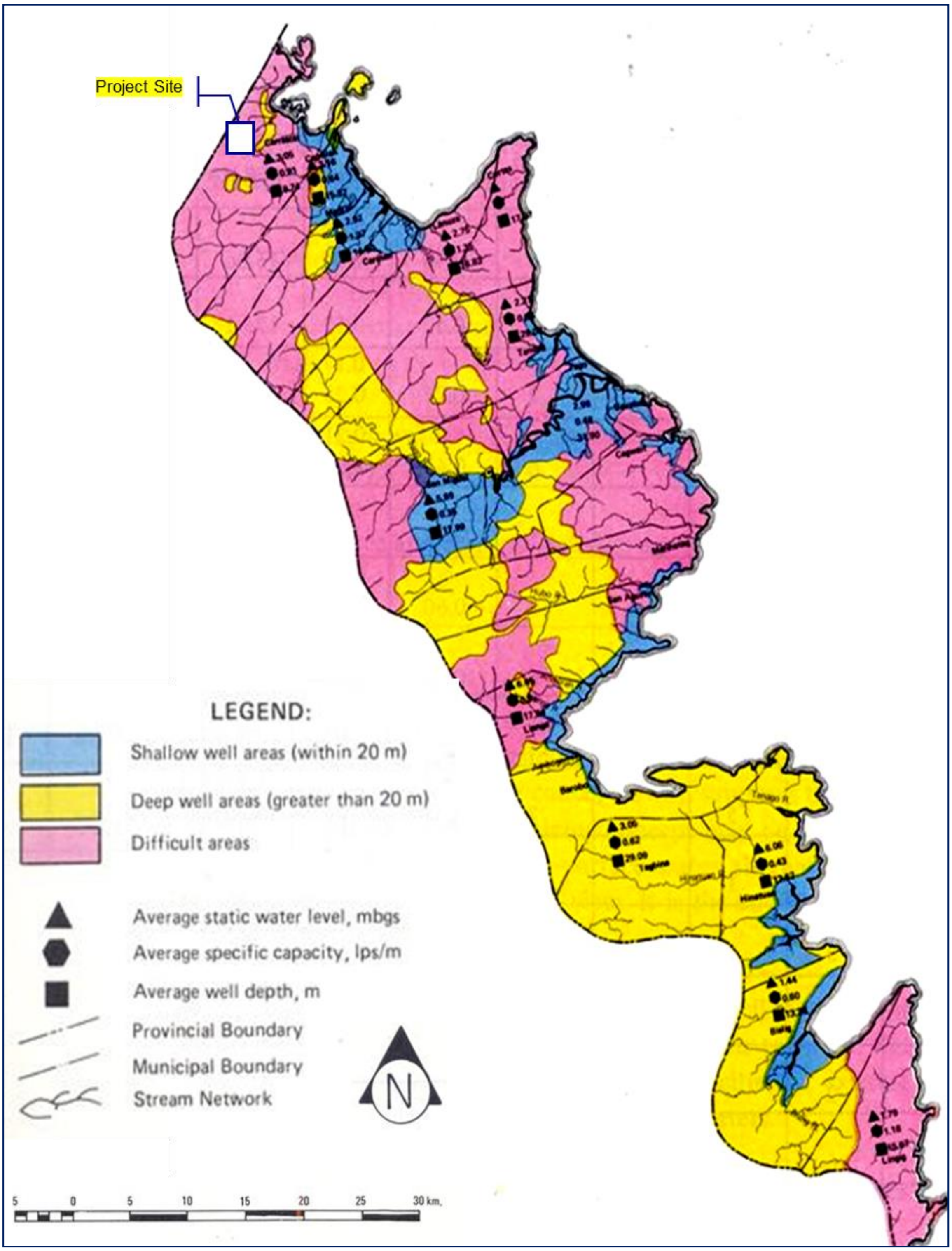
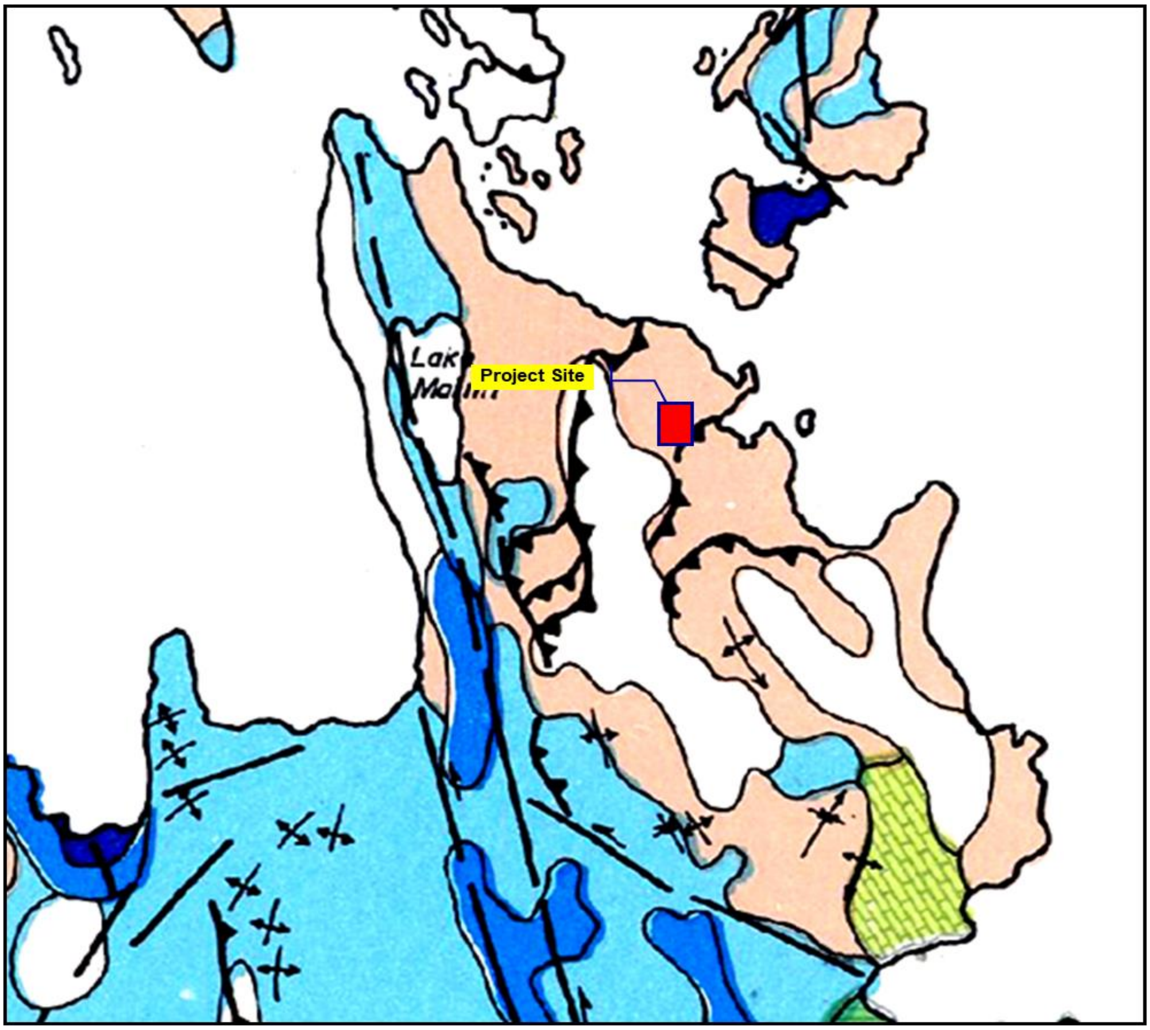


Figure 2.2.6: Groundwater Map of Surigao del Sur



Legend:

Rocks with limited groundwater potential, low to moderate permeability : Cretaceous to Paleogene basic and ultramafic rocks; mainly layered gabbro, dunite and peridotite, the last two are commonly serpentenized. Shallow water yields of <0,01 to 0.3 lps. Higher yields are obtainable in fracture zones.

Rocks without any known significant groundwater obtainable through drilled wells, largely untested: Cretaceous to Paleogene basic and ultrabasic rocks, composed mostly of serpentinized dunte and peridotite and layered gabbro.

Extensive and highly productive aquifers: With an average potential recharge of 0.5 to 1.0 m, greater near influent rivers, with known production well yields mostly between 50 to 100 lps but as high as150 lps in some sites. High to very high permeability.

STRUCTURAL SYMBOLS :

Local and less productive aquifers: Well yields mostly about 2 lps but as high as 20 lps in some sites. Very low to moderate permeability.

High-angle fault, arrow shows relative direction of strike-slip movement

Normal fault, hachures on downthrown side, dashed where inferred

Thrust fault, saw-teeth on overriding side, dashed where inferred

Boundary of lithologic unit

Anticlinal axis with plunge

Overturned anticline

Synclinal axis with plunge

Figure 2.2.7: Hydrogeological Map of the Provinces of Surigao del Norte and Surigao del Sur

2.2.1.8 Change in Drainage Morphology/Inducement of Flooding/Reduction in Stream Volumetric Flow

Rivers that carry a high sediment load will eventually silt up. When siltation reaches the drainage systems at the lowlands, the normal flow of water is impeded and will cause localized flooding during the rainy season. Areas near heavily silted drainage lines will be more prone to this type of flooding. The river bed at the downstream portion may be affected during operation due to earth movement. Prior to their construction, temporary sediment control measures shall be installed. Vegetation cover especially trees within the required legal easements for rivers and riparian zones shall be maintained.

2.2.1.9 Change in Stream and Lake Water Depth

Sediments could be transported to the river systems by surface runoffs. This would lead to blockages and rise in the depth. Sedimentation ponds will constructed on the project site to minimize the sediments going into the rivers from the mining activities.

2.2.1.10 Depletion of Water Resources / Competition in Water Use

The main source of potable and domestic water supply for Brgys. Pantukan and Adlay, Carrascal, Surigao del Sur is surface water tapped from streams of higher elevation than that of the communities. The base flows that feed the stream comes from the fractured ultramafics. There is enough supply of water for the communities during the rainy period wherein the demands are met sufficiently by their respective water supply systems but come the dry season, these supplies are affected and may need whatever help they may need. Groundwater levels in the above aquifers are not of the same level. The alluvial aquifer has shallow water table while that of the ultramafics is erratic depending on the location of the fractured zones. The water level follows the topography, deeper in hillslope and shallow towards the coastline. The flow direction is from the hill to the sea or valleys.

There will be no competition in water use because the project will not use heavy water requirement. The water use will be focused on domestic use which will come the surface water tapped from streams of higher elevation than that of the communities and for dust management system which will come from stored water in siltation ponds which will be reused for water sprinkling.

2.2.2 Water Quality

2.2.2.1 Freshwater Quality

The existing uses of the drainage systems in the area subscribe to the description of Class B Water based on Table 1 of the Water Quality Guidelines of 2016 (DAO-2016-08).

To determine the present quality of water in the different drainages emanating from the mining claim and auxiliary areas, samples were taken and brought to the laboratory for analysis. EMB Region 13 Laboratory was requested to analyze the biological and physical parameters of water samples while the University of Immaculate Concepcion' Science Research Center analyzed the other set of samples for chemical parameters such as pH, Turbidity, TSS, Total and Fecal Coliform and toxic heavy metals such Mercury, Lead, Cadmium, and Hexavalent Chromium.

All water quality parameters have concentrations that are within the limits set by DENR except for Cadmium in Station R1 and TSS in Station FW2. Other concentrations of toxic heavy metals are almost nil (**Tables 2.2.6** to **2.2.8**).

Table 2.2.6: Results of Freshwater Quality Analyses for Chemical Parameters

Parameter	R1 Pantukan	R2 Panikian	R3 Marga	R4 Adlay	DENR Standard	Method
O&G, mg/L	<1	<1	<1	<1	1	Part-Grav

As, mg/L	<0.002	<0.002	<0.002	<0.002	0.01	SDMC
Cd, mg/L	0.051	<0.003	<0.003	<0.003	0.003	AAS
Cr^{+6}, mg/L	<0.010	<0.010	<0.010	<0.010	0.01	DCC
Pb, mg/L	<0.010	<0.010	<0.010	<0.010	0.01	AAS
Hg, mg/L	<0.001	<0.001	<0.001	<0.001	0.001	AAS

Table 2.2.7: Results of Freshwater Quality Analyses for Physical and Biological Parameters

Sample Code	FW1	FW2	FW3	FW4	DENR Standard	Method
River System	Pantukan	Panikian	Marga	Adlay		
pH	8.04	7.80	7.60	7.44	6.5-8.5	Glass Electrode
Temperature, °C	27.91	27.74	28.12	27.96	26-30	Hg-Fi led Thermometer
Conductivity, µS/cm	0.173	0.131	0.122	0.113	-	Horiba U-50 WQ Checker
Salinity, ppt NaCl	0.1	0.1	0.1	0.1	-	Horiba U-50 WQ Checker
Turbidity, NTU	15.9	143	9.7	15.1	-	Nephelometric Method
Apparent Color, PCU	10	125	10	10	-	Visual Comparison
TDS, mg/L	112	85	79	73	-	Horiba U-50 WQ Checker
TSS, mg/L	5	118	2	5	65	Gravimetric dried @105°C
DO, mg/L	8.4	6.9	8.3	7.7	5.0 (min)	Azide Modification
BOD_5, mg/L	0.2	0.6	0.4	0.	5	Azide Modification
T.Coli, MPN/100 ml	330	7900	490	540,000	-	Multiple Tube Fermentation
E.Coli, MPN/100 ml	230	2200	140	540,000	-	Multiple Tube Fermentation

BDL – Below Detection Limit

Table 2.2.8: Results of Laboratory Analyses for Sediment Samples taken from the River Systems

Parameters	SD1	SD2	SD3	SD4	Dutch Intervention Value	Method
	Pantukan	Panikian	Marga	Adlay		
As, µg/g	0.050	0.050	<0.050	0.050	60	SDMC
Cd, µg/g	2.08	1.84	2.70	2.12	6	AAS
Cr+6, µg/g	<0.25	<0.25	<0.25	<0.25	30	DCC
Pb, µg/g	<0.20	<0.20	<0.20	<0.20	75	AAS
Hg, µg/g	<0.02	<0.02	<0.02	0.02	0.3	AAS

2.2.2.2 Marine Water Quality

Carrascal Bay is the principal coastal impact area of the proposed project, specifically coastal waters fronting the coastline of Barangay Adlay. The present use of the Carrascal Bay, Carrascal, Surigao del Sur Bay may be categorized as Class SC. Carrascal Bay opens up to the Pacific Ocean on an easterly direction. The inner sea of the bay is characterized by an extensive shelf of sand and muddy substrate, with mangroves fringing the coastline. The inner shallow sea of Carrascal Bay is fed by at least four (4) river systems. Extensive fringing reefs occur at the mouth of the inner bay, specifically in around Ludguron Island and in the coast of Barangay Dahican.

To determine the present quality of water in the coastal areas that can potentially receive effluents from the mining site, two (2) samples were collected at the coastal area of Adlay and another sample was taken from coast of Doyos. Sediment samples were also taken from both the coasts of Adlay and Doyos. The emphasis of the water quality study was on the physical characteristics of marine water which can be expressed in turbidity and the concentration of Total Suspended Solids or TSS. Heavy metals were also considered particularly mercury, cadmium, hexavalent chromium and lead. The physical and chemical analyses of samples were done by the University of Immaculate Concepcion (UIC) in Davao City while the biological analyses were carried out by EMB Region 13.

The analysis of results of marine water show relatively low values for TSS and Turbidity in Stations CW-1 and CW-3 indicating that sediment deposition on the seabed is significant even as coastal waters are affected by turbid waters emanating from the estuaries. On the toxic heavy metals analyzed, none exceeded the standards for Class SC Waters. On the biological side, the total coliform counts are high due possibly to the settlements in the coastlines.

Tables 2.2.9 and **2.2.10** present the results of marine water quality analyses. **Table 2.2.11** presents the results of laboratory analyses for chemical parameters of marine sediment samples.

Table 2.2.9: Results of Marine Water Quality Analyses for Chemical Parameters

Parameter	MW1	MW2	MW3	DENR Standards	Method
Coastal Area	Adlay	Doyos	Adlay		
O&G, mg/L	2	1	1	3	Part-Gravi
As, mg/L	<0.002	0.002	<0.002	0.02	SDMC
Cd, mg/L	0.003	0.004	<0.007	0.005	AAS
Cr+6, mg/L	<0.010	<0.010	<0.010	0.05	DCC
Pb, mg/L	<0.010	<0.010	<0.010	0.05	AAS
Hg, mg/L	<0.001	<0.001	<0.001	0.002	AAS

Table 2.2.10: Results of Marine Water Quality Analyses for Physical and Biological Parameters

Parameter	CW-1	CW-2	CW-3	DENR Standard	Method
Coastal Area	Adlay	Doyos	Adlay		
pH	7.11	7.50	7.07	6.5-8.5	Glass Electrode
Temperature, °C	27.87	27.89	27.96	25-31	Hg-Fi led Thermometer
Conductivity, *µS/m2*	3.54	0.382	3.49	--	Horiba U-50 WQ Checker
Salinity, mg/L	1.9	0.2	1.8	-	Horiba U-50 WQ Checker
Turbidity, *NTU*	13.4	285	14.0	-	Nephelometric Method
Apparent Color, *PTU*	10	300	10	-	Visual Comparison
TDS, *mg/L*	2,270	216	2,230	-	Horiba U-50 WQ Checker
TSS, *mg/L*	23	177	1	80	Gravimetric dried @105°C
DO, *mg/L*	6.7	7.6	7.4	5.0	Azide Modification
Total Coliform, *MPN/100 ml*	26000	2700	28000	-	Azide Modification
Fecal Coliform, *MPN/100 ml*	130	680	22000	200	Multiple Tube Fermentation

Table 2.2.11: Results of Laboratory Analyses for Chemical Parameters of Marine Sediment Samples

Parameter	S1	S2	Dutch Target Values	Dutch Intervention Values
Location	Adlay	Adlay		
Arsenic, As, µg/g	0.075	0.100	29	55
Cadmium, Cd, µg/g	1.74	2.24	0.8	12
Hexavalent Chromium, Cr+6, µg/g	<0.25	<0.25	100	380
Lead, Pb, µg/g	<0.20	<0.20	85	530
Mercury, Hg, µg/g	<0.02	<0.02	0.3	10

2.2.2.3 Degradation of Water Quality

The quality of water in all drainage systems meets the criteria of the Class B Waters (Recreational Water Class I). This is described as water used for primary contact recreation such as bathing, swimming, skin diving, etc. (particularly those designated for tourism purposes).

Since the environmental quality of sediments can in a way affect the quality of water, these were sampled for analysis of some toxic heavy metals like arsenic, cadmium, lead, mercury, and hexavalent chromium. Cadmium concentrations are significantly high and exceeded the Target Values of the Dutch standards for soil and sediments but way below the Intervention Values. The metals can be released to the marine water and become available for intake by low-level species in the food chain. In addition, because lead and cadmium are persistent in the environment and in marine species, they therefore can accumulate in species of the upper level of the chain and finally become available for human intake. High cadmium values were determined by experiments to have carcinogenic effects to the human body.

In conclusion, the background values of cadmium in the project site are high. This metal is found in the different environmental compartments namely, soil, sediments, water and biota. The bioaccumulation of cadmium is evident in the fish and most probably this is carried to the residents of Carrascal, Surigao del Sur and other communities surrounding the water bodies.

2.2.3 Freshwater Ecology

Freshwater ecology assessment was conducted in March 2021 to document freshwater fish biota infaunal benthic benthos and macro-invertebrates present in the river sampling stations. In as much as no fishers were encountered in the two-day survey, key informant interviews with local fishers were conducted to catalogue fish and macro-invertebrate diversity from anecdotal accounts of freshwater fisheries productivity.

Three river systems – Kay-ongan River, Nasipit River and Marga-Adlay/Pantukan River are the main freshwater bodies that traverse the highlands of Claver-Carrascal and are the possible conduits of sediment-laden waters from the mining project. The Kay-ongan River flows out about 3 km north of Bgy Adlay proper, the Nasipit River lies in the central portion of inner Carrascal Bay while the Marga/Adlay River is close to the Barangay proper (**Figure 2.2.8**). The Nasipit and Pantukan River, the latter merging with Marga River in its upper slopes, meanders through the project site. While all the rivers are perennial, many portions diminish during the dry season and sandy deposits can be found along the banks of bends in the rivers. The upper reaches are narrow while the lower portions where the survey stations were located, are relatively wide, averaging 10 to 12 m breadth but with abrupt narrow tapering in some sections in the Kay-ongan and Nasipit Rivers (**Plate 2.2.2**).

The sampling stations are located in low-gradient portions of the river, averaging 500 m upstream from the estuary, with small boulders, loose rocky substrates, and cobbles subjected to high-flow events forming high-gradient riffles during periods of heavy rainfall. Riffles are slowed down by pools in portions of the river near the estuary basins, and particulate deposition from riparian canopy and riverbank foliage increases as water velocity slows in pools. Other than mangroves, the river sampling stations are largely open-canopy. Silt and sediments are vividly suspended in the water column of the rivers, causing high turbidity. In the Kay-ongan River, the sediment intrusion is heavy, causing brown-colored river water

Three observation stations – one each in each river system, were conducted. Boat-based observation was conducted in each river system; thence observation walks in the next 300 m. The coordinates are enumerated in **Table 2.2.12** and shown in a map in **Figure 2.2.9**.

Table 2.2.12: Coordinates of Freshwater Ecology Sampling Stations, March 2021

Code	Latitude	Longitude	Remarks
RVR1	N 09.418870°	E 125.888699°	About 600 m inside the river. Nasipit River; Width: 6-8 m; Depth at Station: 1-3m; Substrate: Mud; River Uses: None at time of sampling; Riverbank Vegetation: Mangroves
RVR2	N 09.404033°	E 125.899063°	Adlay-Marga River about 500 m from the estuary; Width: 12-15 m; Depth at Station: 1-3m; Substrate: Mud, Sand, Pebbles; River Uses: Boat Navigation; Riverbank Vegetation: Mangroves
RVR3	N 09.435901°	E 125.900074°	Kayungan River; Width: 6-12 m; Depth at Station: 0.7-2m; Substrate: Mud and Sand; River Uses: None at time of sampling; Riverbank Vegetation: Mangroves

2.2.3.1 River Sampling Station Characteristics

Kay-ongan River

The Kay-ongan River emanates from the Carrascal highlands and flows in a northeasterly direction before emptying in the northeast corner of inner Carrascal Bay more than a kilometre away from the Barangay proper. Mangrove trees line up the riverbanks and no commercial crops were seen. The water of this river is heavily silted with silt and sediments vividly rendering brown-colored water (Plate 2.2.2). With no ripples, stream flow is sluggish and no fishing operation was seen during the survey. Fishers near the area who were interviewed claimed that several species of fish use to inhabit the river, including 'bugaong' (convex-lined theraponid *Therapon jarbua*), 'kasili' (freshwater eel *Anguilla sp*), "pantat" (river catfish *Clarias sp*), tilapia (*Oreochromis sp*) and the local "Bia" (Goby; Family Gobidae). However, key informants claim that the disappearance of the usual fish species and the loss of fisheries productivity subsequently deterred observed in the calmer portions of the river, particularly in pools. Indeed, no significant fishing activities, aquaculture or stationary fishing gears (e.g., 'baklad') were encountered in the sampling area and contiguous river lagoons

Nasipit River

The river has an approximate width of 6 to 8 m with muddy substrate strewn with small rocks along the banks. Eroded soil is visible in the water column. The depth is approximately 1 to 3 m in the midsection. Mangroves grow along the riverbank; there is a marked absence of other riparian vegetation. Key informants living near the river estuary claim that there are no fishing activities or river recreational activities being undertaken in the Nasipit River due to the increade turbidity in recent years. Subsequently, there were no fishing activities observed at the time of the survey and no set traps were seen in a 300-m observation walks. River biota was insignificant with only sporadic occurrence of the freshwater snail (Thiaridae) and swamp cerith (*Terebralia* sp) observed in opportunistic surveys for macro-invertebrates. Test fishing using a cast net in calm areas suspected to refuge aquatic organisms yielded no fish species

Marga/Adlay River

The river's estuary is situated approximately 400 m from the main population center of Brgy Adlay, the Adlay River connects with the Marga River about 1 km from its estuary before it flows out into Carrascal Bay. Its watershed is approximately more than 3000 ha in the Carrascal highlands. Marga River has a gravel type of substrate with medium to large size rocks in muddy substrate. The width of the river is approximately 20 m with very slow-moving water from the midstream section that would completely dry up during prolonged dry season. The upstream section however has moderately rapid waters with rock boulders at both sides of the banks forming ripples. Vegetation in the downstream section is comprised of mangroves while upstream portions consist of patches of commercial species of trees, coconut and shrubs.

Plate 2.2.2: The Nasipit River (upper left), Kay-ongan River with extremely turbid waters (upper right) and the Adlay River with thin mangrove strip lining up its banks (lower)

Figure 2.2.8: Location Map of Three River Systems Near the Coastal Impact Area of the Proposed Project

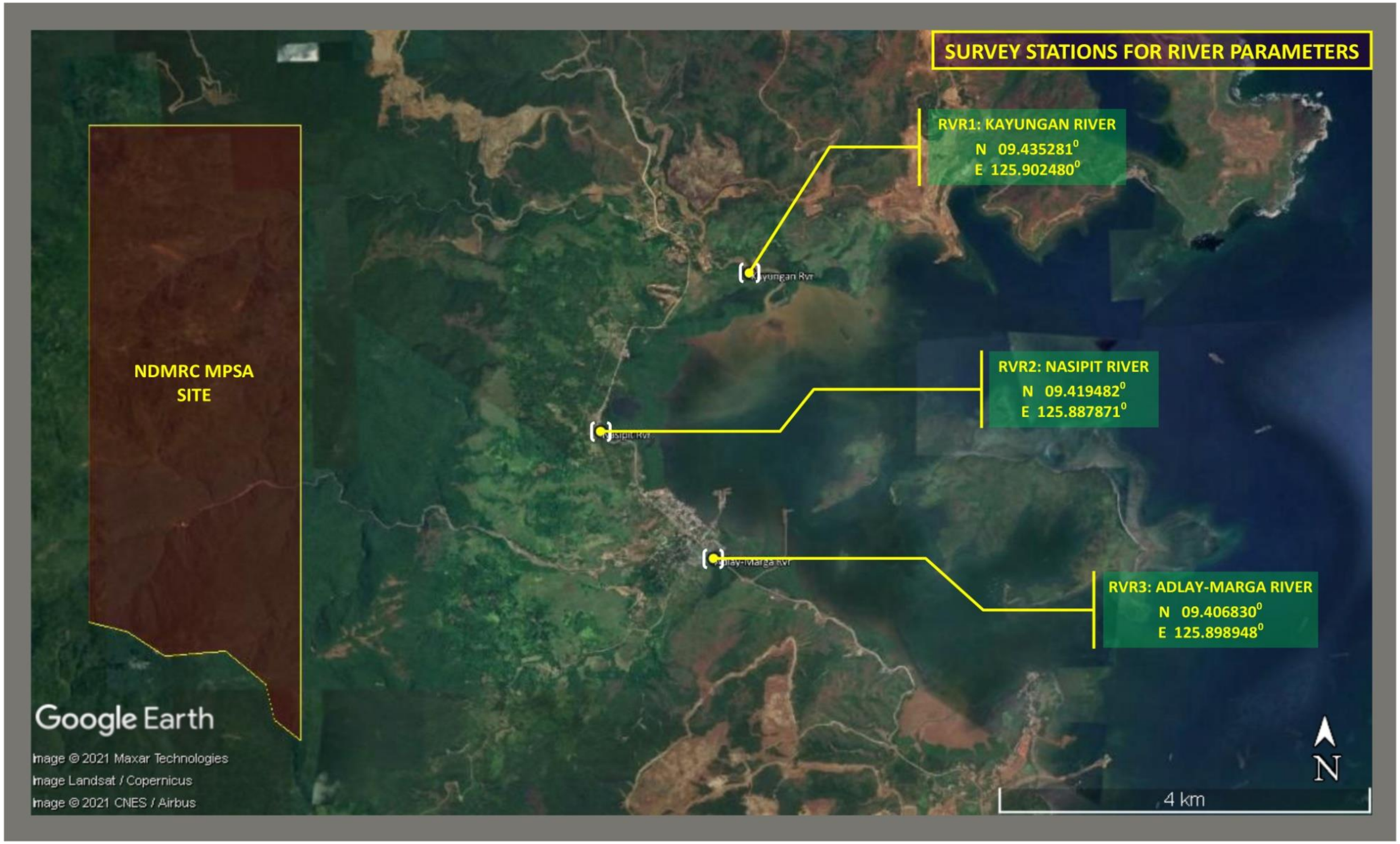


Figure 2.2.9: Location Map of Freshwater Ecology Sampling Stations

2.2.3.2 Fish Biota

Determination of common species of fish in the river, if present, was undertaken through key informant interviews and actual fishing using a cast net (**Plate 2.2.3**). Actual observation of fish species in the upstream stations were undertaken through opportunistic observations in river pools with submerged vegetation and natural fish shelters along shallow and calmer portions of the river. However, the turbid waters have rendered the investigations unfeasible. Too much turbidity has also made transect swims for fish identification impractical. The coordinates and the location map of the actual fishing stations are presented in **Table 2.2.13** and **Figure 2.2.10**.

Table 2.2.13: Sampling Stations for Fish Biota Assessment

Station	Latitude	Longitude	Remarks
TFS1	N 09.435210°	E 125.904920°	Using cast net in Kayongan River, Barangay Adlay, Carrascal, Surigao del Sur; negative for catch during sampling time
TFS2	N 09.419950°	E 125.890610°	Using cast net in Nasipit River, Barangay Adlay, Carrascal, Surigao del Sur; negative for catch during sampling time

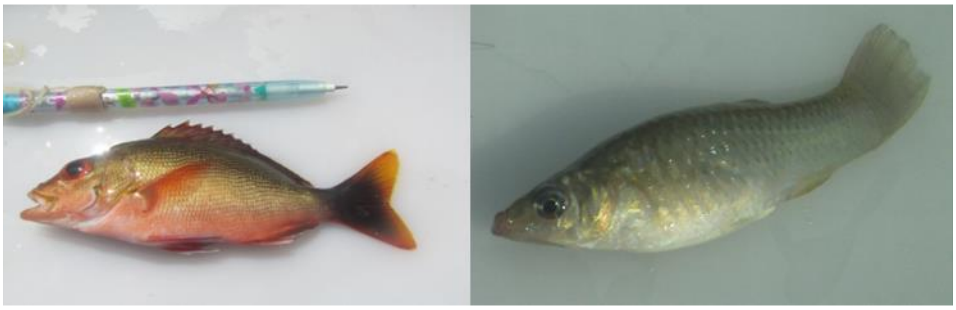
Plate 2.2.3: Actual Fishing Being Conducted by the Survey Team

Figure 2.2.10: Location Map of Actual Fishing Stations; March 2021

Repeated test fishing using a cast net in the Nasipit and Kay-ongan Rivers yielded no catch except for one (1) small mangrove snapper (*Lutjanus argentimaculatus; mangagat)* caught near the estuary. However, fishers living near the Nasipit and Adlay Rivers who were interviewed on the presence of fish species in the river claimed that several species of fish previously inhabit the river, including 'bugaong' (convex-lined theraponid *Therapon jarbua*), 'kasili' (freshwater eel *Anguilla sp*), "pantat" (river catfish *Clarias sp*), tilapia (*Oreochromis* sp) and the local "Bia" (Goby; Family Gobidae). In addition, key informants claim that the "pasayan" (*Nematopaleomon tenuepsis*) were occasionally seen in the river albeit in very small numbers in previous years. However, a 100-m river transect walk to spot fish or crustacean species in riparian areas and stream pools yielded negative results even with the use of a scoop net. Key informants declared that fish have disappeared in the river, presumably brought about by sediment intrusion and turbid water. Due to this, fishing was no longer undertaken in the river. The list of the few fish species previously inhabiting the river is presented in **Table 2.2.14**; **Plate 2.2.4**.

Table 2.2.14: List of Fish Species in Habiting the Adlay and Nasipit Rivers as Divulged by Fishers, March 2021

English Name	Local Name	Scientific Name	IUCN Status
Mangrove snapper	Mangagat	*Lutjanus argentimaculatus*	*Least concern*
Convex-line theraponid	Bugaong	*Therapon jarbua*	*Unknown/Data deficient*
Phil river catfish	Pantat	*Clarias sp*	*Least Concern*
Freshwater eel	Kasili	*Anguila sp*	*Data deficient*
Giant freshwater prawn	Ulang	*Macrobrachium rosenbergii*	*Least Concern*
Nile tilapia	Tilapia	*Oreochromis niloticus*	*Least Concern*
Spotted barb	Pait	*Pontius binolatus*	*Unknown*
Dark-margined flagtail	Damagan	*Kuhlia marginata*	*Least Concern*
Chevron snakehead	Dalag/Haluan	*Channa striata*	*Least Concern*
Endeavor shrimp	Pasayan/hipon	*Nematopalaemon tenuepsis*	*Not assessed*
Goby	Biya	*Glossogobius sp*	*Not assessed*



Note: left: mangrove snapper; right: spotted barb.

Plate 2.2.4: Two Species of Fish Observed in the Adlay River, March 2021

2.2.3.3 Macro-Invertebrates

Macro-invertebrates, as indicator of ecosystem health, can be categorized based on their tolerance to pollution conditions (IOWATER, 2012). Group 1 (sensitive) are organisms that cannot survive under polluted conditions thus their presence indicates good water quality. Group 2 (facultative) are organisms that can exist under a wide range of water quality conditions than sensitive organisms can. Group 3 (tolerant) are organisms that are tolerant of pollution; in large amounts, they point to poor water quality conditions but can also be present in good and fair water quality (IOWATER, 2012). The coordinates of stations for macro-invertebrate sampling are listed in **Table 2.2.15**; the location of the survey stations is presented in **Figure 2.2.11**. Photographs of benthos samples are also presented in **Plate 2.2.5**.

Table 2.2.15: Sampling Stations for Macro Benthos Assessment

Station	Latitude	Longitude	Remarks
FMAC1	N 09.435210°	E 125.904920°	Rayed pearl oyster (*Pinctada imbricata*), "Dayo-dayo", and Algae sea snail (*Nerita polita*) at Kayongan River, Barangay Adlay, Carrascal, Surigao del Sur
FMAC2	N 09.419410°	E 125.893080°	Crass turban sea snail (*Turbo crassus*), Punctate codakia (*Codakia punctata*) "Litob" and Brown fox seashell (*Pleuroploca filamentosa*) at Nasipit River, Barangay Adlay, Carrascal, Surigao del Sur
FMAC3	N 09.407160°	E 125.901700°	Interviewed gleaner coming from Purok - 6 Barangay Adlay, Carrascal, Surigao del Sur. Gleaned macro-invertebrates were: Pyram top shell *(Tectus pyramis)* "Tuwad-tuwad", Gold-mouth turban *(Turbo chrysostomus) "Takdagon"*, Venus clam *(Pitar herbraeus) "Buronay"*, and *(Vasticardium angulatum) "Litob"*.

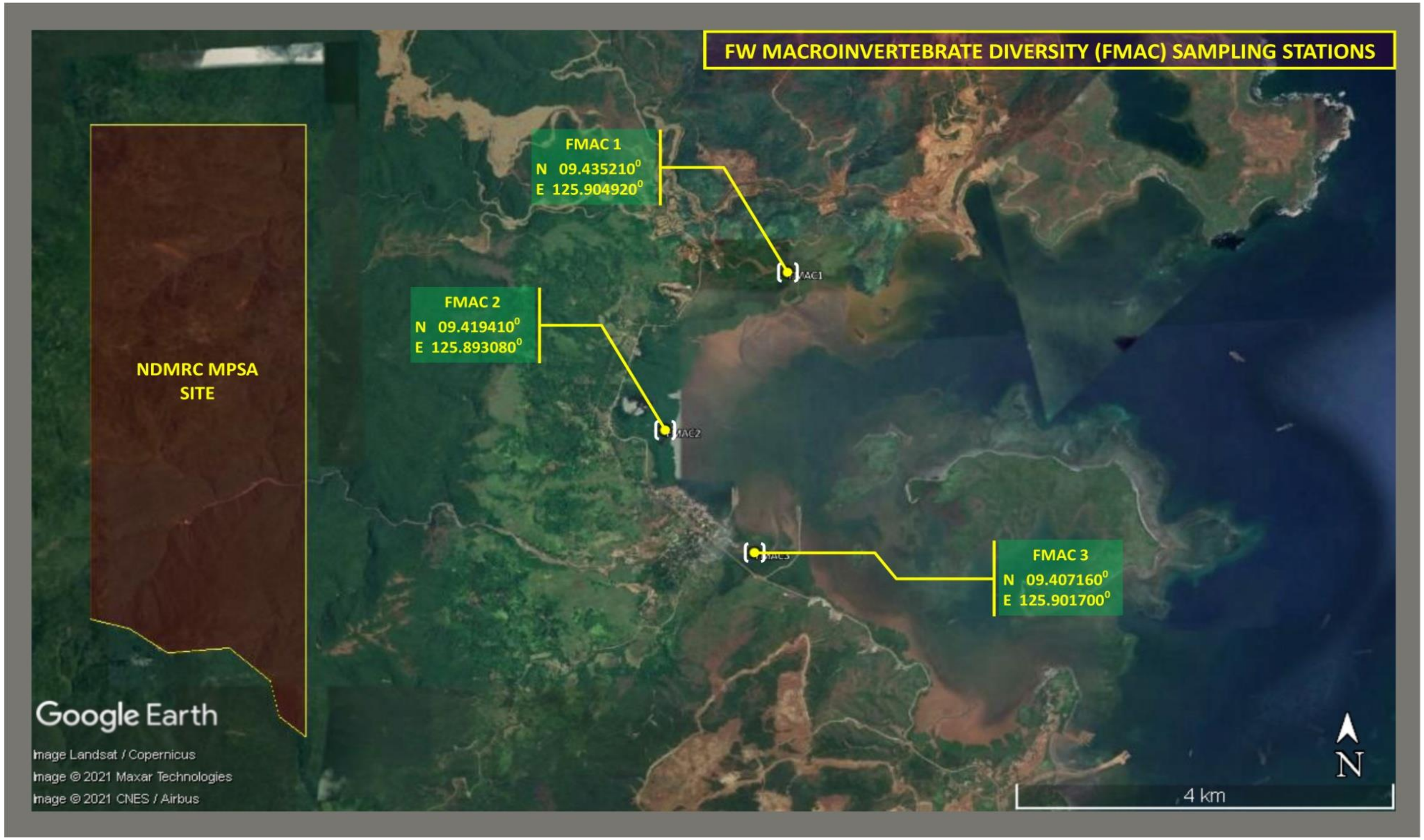


Figure 2.2.11: Location Map of Sampling Stations for Macro-Invertebrates in the Nasipit, Kang-ongan and Adlay-Marga Rivers

In this survey, most of the remaining macroinvertebrates seen fit in Group 3. There were few macro-invertebrates of commercial significance for food or trade observed in all three river stations indicating species deficiency. Three (3) species of macro invertebrates – the freshwater swamp cerith *Terebralia sulcata,* costate algae nerith *Nerita poltata* and Thira snails were seen in the banks of the Nasipit River, mostly attached to mangrove trees. All have no economic value. *Thiara* snails (*Melanoides* sp) are considered invasive herbivores and bioturbators. In terms of conservation status, it is categorized as "least concern" according to the IUCN red list of threatened species indicating that that no conservation action is needed. Ecologically, all three species are very adaptable and resilient in various environmental conditions with species commonly found in rivers including tidal areas, and lakes, and a wide variety of anthropogenic habitats including pools, and canals. In the Adlay River however, key informants from Purok 6, Barangay Adlay claim that macro-invertebrates of significant value for food have been previously collected in the river. These include Rayed pearl oyster (*Pinctada imbricata*), pyram top shell *(Tectus pyramis*; "Tuwad-tuwad"), Venus clam *(Codakia punctata; "Litob")*, and crass turban sea snail (*Turbo crassus*); (**Plate 2.2.5**). These species are allegedly not collected anymore at present and residents near the river accuse excessive sediment intrusion as the cause of disappearance. The highlights of macro-invertebrate findings are displayed in **Figure 2.2.12**.

Note: top row: tree oyster and hammer oyster, swamp certith, algae nerith and Thiarid snalis. Last two photos in the bottom row are specimens of macro-invertebrates that allegedly previously existed in the Adlay River: venus clam (Litob) and trumpet snail Turbo crassus.

Plate 2.2.5: Macro-invertebrates that presently inhabit the Nasipit and Adlay Rivers

Figure 2.2.12: Highlights of Investigations on the Presence of Macro-Invertebrates in the Nasipit, Kang-ongan and Adlay-Marga Rivers; March 2021

2.2.3.4 Presence of Pollution Indicators Species

There are no species of fish and shellfish that can be employed as bio-indicators of biotoxin pollution. Epibenthic fauna (macro invertebrates or macro benthos), on the other hand, serve a number of ecosystem roles at various levels of the food chain, ranging from consumers of plant material to prey for fish. Macro-invertebrates are good integrators of environmental conditions over time and can be used as indicators of heavy metal pollution, especially sessile, filter-feeding macro-invertebrates. However, no significant population of bivalves have been observed in the three river systems and were in fact completely absent in the Kay-ongan River. The absence of a significant population of macro-invertebrates is indicative of a habitat that is not conducive to growth of a population of bivalves and gastropods and this can be an indication of a polluted river system. In this case, heavy sediment load and riverbed alteration can be a causative factor for the decline in macro-invertebrate population.

2.2.3.5 Threat to Existence and/or Loss of Important Local Species and Habitat

In situ water ecological data obtained from the survey in the three river systems suggests that with the exception of the Marga/Adlay River, the two other major river systems around the project site are already unsuitable for survival of aquatic biota. Along this line it is important that protection of the integrity, and in fact promotion of improvement and maintenance of its water quality, be pursued.

The absence of significant foodfish, macro-invertebrate and other fauna diversity in all of the river systems investigated signify a highly deteriorated biological environment. Endemic mudfishes and catfishes were no longer reported to occur in the river systems surveyed. Any further threats to the integrity of the said bodies of water are significant if populations of aquatic fauna will revive. As such, prevention of further degradation should be emphasized in all the rivers.

2.2.3.6 Threat to Abundance, Frequency and Distribution of Species

There were no reports of the occurrence of the rare river mullet (Pigok; *Mesoprisites cancellatus*) in the areas surveyed. The Tilapia and Dalag, as well as the species of macro-invertebrate shellfish existing in the rivers, albeit in very low abundance, are valuable food fishes but most are of juvenile sizes, indicating growth overfishing most probably caused by extensive use of electro-fishing in previous years and current pollution loads. The low species density and abundance is indicative of a deteriorating habitat condition. The extremely polluted nature of the Kay-ongay River has caused the absence of standing stocks of fish of any species.

Degradation of Water Quality from Sediments and Silt

Earthmoving will result to sediment spills into the river system, altering fish and crustacean habitats, blockage of migration pathways and fish feeding grounds; all of which will lead to significant decline in fish and crustacean populations and ultimately, loss of incomes of local fishers. Sediments carried down from soil erosion and earth moving due to mining operations and construction-related activities such as land clearing and soil stock piling may end up as runoff to the river systems especially during storm and heavy rains. This may adversely cause water turbidity and stream flow obstruction and affect fish and the remaining macro benthos fauna. Sediment erosion in freshwater bodies can cause localized mortality of aquatic larval forms of bivalves and gastropods, as well as impair nesting grounds of fish. Larger sediment grains and loose soil can be retained in deeper portions of the river systems and this can disturb fish breeding and grazing areas for bottom dwelling biota. If erosion and loose soils cannot be effectively controlled, the effect will be progressive siltation in the river systems. Changes in ecological conditions in a stream often lead to changes in the community structure of benthic animals. It is presumed that previous mining operations and flash floods have carried significant debris that altered the riverbed conditions resulting to a highly degraded macro invertebrate community. This poor condition of the fish and macro invertebrate community is likely related to sedimentation, erosion, and run-off from large upland areas that have been cleared of vegetation. The introduction of disturbances to which river organisms have had no previous exposure can significantly alter the habitat and behavior of river organisms and disrupt grazing and migration pathways leading to failure of recruitment or massive migration of fish species into areas of better water quality. Siltation may increase water turbidity, resulting in decreased light penetration and a decrease in photosynthetic function of primary producers such as phytoplankton and benthic algae.

Moreover, with the presence of suspended laterite soil in river waters during flooding events, the color or river water can drastically change from greenish to rusty brown. Discoloration destroys the aesthetic condition of the river and possibly even in coastal water, and may cause the displacement of both pelagic and demersal species of fish seeking refuge and feeding grounds in the estuaries.

The primary mitigation strategy to prevent fugitive sediments and terrigenous material disturbed during Project establishment and mining operations from being carried to gullies and river systems is the establishment of a series of sediment mitigation structures, including catchment and settling ponds, in strategic points to ensure that silt and sediments will not wantonly flow into the rivers. This will include installation of basins and canals where rainwater are diverted and contained. Loose soil run-off and sediments from water run-off will be sieved through filters and geotextile materials before water is discharged into project diversion waterways. Such loose soils will be piled up and re-used in reforestation areas. This will be supported by state-of-the-art erosion control measures that will include trench diaphragms, revegetation activities in slopes and open areas. The stabilization of areas where earth moving has occurred will be undertaken in all areas affected by mining and project establishment through extensive vegetation cover enrichment in order to increase sediment amalgamation capacity and soil compacting. Regular *in-situ* monitoring of river water quality and the state of habitats and diversity of aquatic fauna will be conducted.

Degradation of Water Quality from Wastewater and Oil Spill

Increased human presence and settlements in the area during project establishment and construction can lead to river water pollution, and disrupt fish and crustacean life cycles and larval survival. Poorly-managed waste disposal and dust accumulation can lead to contaminants and infiltration of various waste streams generated during construction, as well as domestic wastes generated in all phases of project development and operations. This may adversely affect water and sediment quality in the rivers and exacerbate an already sluggish stream flow in the Kay-ongan River. Further water quality degradation may affect abundance and survival of zooplankton, macrobenthos and fish. It is to be noted however, that because sediments serve as a sink for various nutrients, sediment-associated environmental problems is an issue that cannot be attributed to single point source alone but to a broad range of sources, in many instances, other industrial establishments, domestic wastewater from households, open latrines, fertilized croplands, and denuded watersheds. In all three river systems surveyed, households and croplands border the river banks along the lower slopes.

In addition, the risk of oil and grease contamination of the river will occur if disposal of fuel-based wastes is not undertaken properly and accidental spills near waterways that drain into the river happens. From portions of the river, oily sludge, processing slurry and hazardous wastes can be inadvertently carried to coastal waters if containment, recovery and treatment systems are not efficiently established and maintained. Such fugitive wastes will have far-reaching and irreversible impacts on benthic communities in the estuary, resulting to contamination of grazing areas that may depress fish growth and recruitment, and loss of fish habitats.

To minimize or prevent degradation of the three river systems around the project site, the following measures will be adopted:

- Engineered drainage systems which will include siltation ponds, stabilization of gullies and construction of run-off weirs at desirable distances along and within the existing gullies will be instituted in order to prevent sediment streams from reaching any freshwater river systems; Construction of sediment controls such as silt fencing or detention basins that trap soil particles in loose river bends and in rapidly flowing portions.
- No part of the river or its tributary creeks will be blocked and the project will ensure fluid discharge and river flows. In view of this, no freshwater fishes, habitats and migration pathways of fish and crustaceans will be affected.

- Construction stockpiles shall be covered and rigidly bundled away from areas where spillage onto the river systems can occur;
- Vehicles carrying construction materials shall be covered and speed limits will be imposed.
- Heavy equipment areas will be located away from waterways where erosion control measures can be easily applied. Construction stockpiles shall be covered and rigidly bundled. As a precautionary approach, slurry walls will be built around areas where such slurries can emanate extensively.
- An oil and grease containment and oily waste containment and recovery plan will be formulated and enforced in all aspects of project operations. Remediation will include recovery and treatment of sludge. Carpools will be located farthest from river systems and all vehicle oil discards will be recovered and discarded in inland waste management systems.
- Drainage canals shall be engineered to trap and prevent sediment from being washed into nearby freshwater bodies of water, especially the Madre Eustaquia creek;
- Modern wastewater treatment facilities and a solid waste management plan will be implemented and strictly enforced as mitigation to potential waste disturbances. This will include the setting up of a wastewater treatment facility in premises where project offices, personnel quarters and mess halls are to be located. State-of-the art modern sanitation facilities with 3-chambered septic tanks will be installed in all project latrines.
- Regular *in-situ* monitoring of water quality will be conducted.

2.2.4 Marine Ecology

The coastal impact area of the proposed project lies mainly in the small bay bordered with patches of mangroves fronting Barangay Adlay, Carrascal, Surigao del Sur (**Figure 2.2.13; Plate 2.2.6**). The coastal impact area in Carrascal Bay is dominated by a wide shelf of mostly mud and sandy substrate in the inner bay influenced by three River systems that all transport various degrees of suspended sediments – the Marga/Adlay River, Nasipit River and the Kay-ungan River. The shelf extends to about 1.3 km from the shore where a narrow slope begins and drops to about 10 m. The muddy shelf is populated by sporadic growths of Sargassum seaweed and isolated patches of the eel seagrass *Enhaulus acoroides* in a cove in near the Barangay proper. The shelf extends to about 1.5 km from the shore where a narrow slope begins and drops to about 10 m. In this area, a fringing reef hugs the coastline of Ludgoron Island and the islet west of its coastline. The corals in this area forms part of the 84 ha Adlay Marine Protected Area (MPA) established in 2010. Across the mouth of the outer bay, a small reef can be found in the Alingating shoal about 2 km from the Barangay proper. On the other hand, extensive mangrove forests can be found in the coastline of Adlay, running about 4 km from the estuary of Kay-ongan River up to the northeastern fringes of the Nasipit (Adlay) River.

A coastal habitat map of the coastal impact area in Barangay Adlay is presented in **Figure 2.2.14**. (**Plate 2.2.6**). The prominent reefs are around Ludguron Island. The reefs in the inner bay have been overcome by sediments and mud and currently host mostly dead corals with algae.

Marine ecology baseline assessment was conducted on 03-05 March 2021and focused on scientifically documenting the existence and condition of a range of ecological niches, resources and resource use practices found within a 5-km stretch of coastline and about 100 ha of coastal waters. The objective of the assessment is to account and describe the condition of primary benthic habitats, its associated fisheries resources, resource use practices and ecological functions that can be potentially disrupted or impaired by project establishment, or be subjected to stresses associated with potential anthropogenic environmental issues attributable to the Project's implementation. The underpinning goal of the baseline assessment and coastal habitat profiling is therefore to illustrate the current condition of habitats and resources in the project's impact area so that these can be comparatively viewed in the future when the project is already operating. By obtaining data and variables of the same types and employing consistent survey protocols, susceptible end points and critical benthic habitats can be characterized in their current state and identification of potential causes and pathways of stressors can be identified for future monitoring purposes. The evaluation is therefore broad and far-reaching, encompassing ecological attributes in order to generate meaningful information that can be the basis for making informed decisions on how to monitor and measure the impacts of the project, and in crafting appropriate response measures to ensure that such project impacts, if any, are mitigated over the long run and in the most effective manner. The survey focused on broad area benthic profiling in Carrascal/Adlay Bay, investigation of the diversity and distribution of corals, documentation of actual fishing in the bay for real time catch per unit effort in fisheries, opportunistic surveys of macro-invertebrates of commercial significance to the local community, river biota and plankton community sampling.

The survey methods employed follow standard marine resource survey techniques prescribed by English *et. al.* (1994) and modified in accordance with *in-situ* conditions following rapid appraisal techniques for coastal resources. In the coastal area directly in front of the project site, a more focused assessment was undertaken with the survey team members undertaking systematic snorkelling and spot dives to determine reef and fish distribution patterns in this focal area. Key informants were interviewed to determine marine capture fisheries condition, and sampling stations to determine presence of macro-invertebrates that are utilized for food and trade were undertaken in river systems and spot dive stations.

Plate 2.2.6: Coastal Waters in front of Barangay Adlay, Carrascal, Surigao del Sur (left) and the Adlay MPA in the Mouth of the Bay with Ludguron Island in the Background (right).

Figure 2.2.13: The Coastal Area in the Proposed Project, March 2021

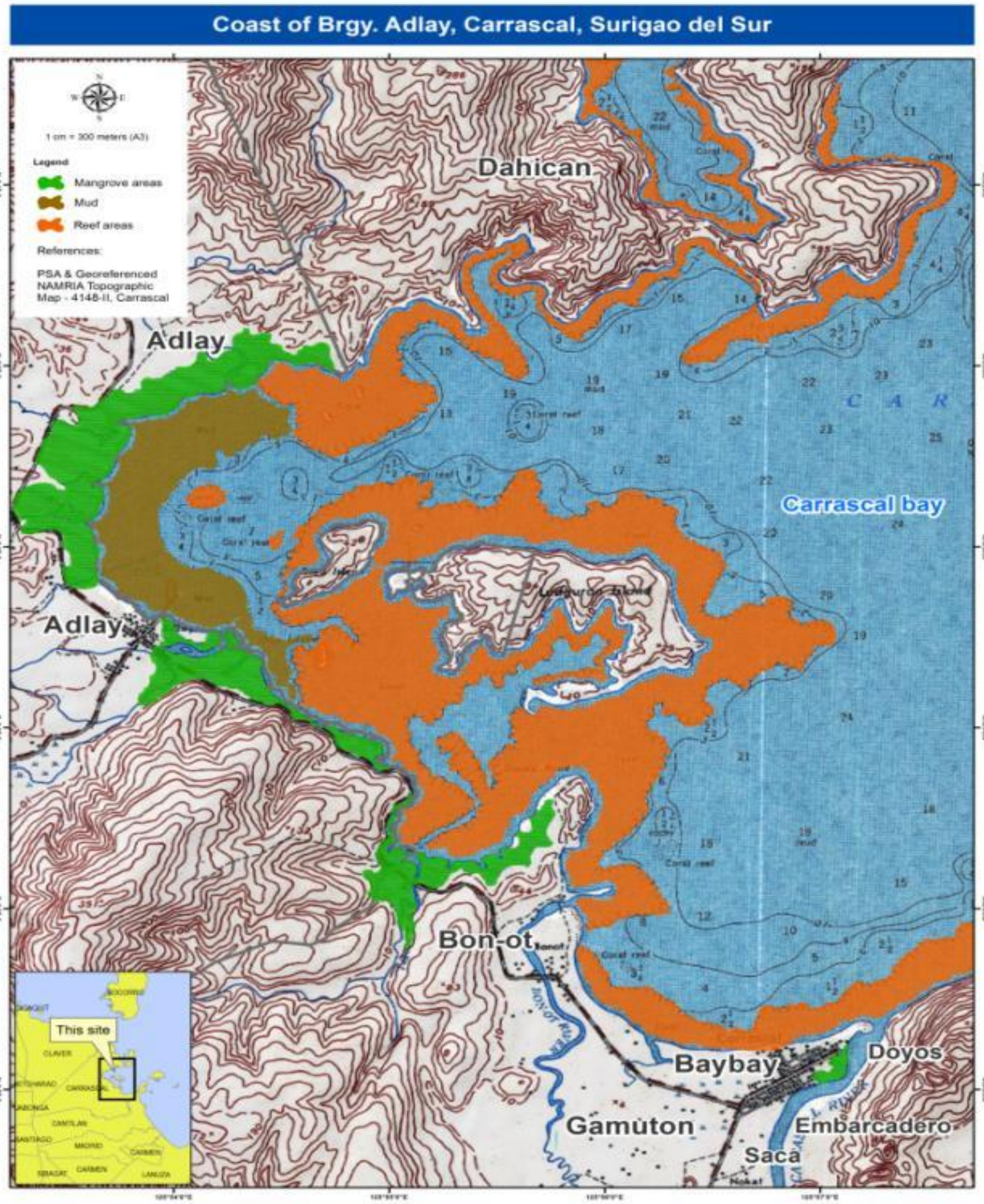


Figure 2.2.14: The Coastal Impact Area and Coastal Habitats in the Coastline of Barangay Adlay

2.2.4.1 Corals

2.2.4.1.1 Corals – Broad Area Profiling (Manta Tows)

Manta tow surveys were conducted in continuous stations in order to determine benthic condition over a long stretch of seabed inside and outside of the project's primary impact area. Manta tow is a useful method in generating a general profile of benthic resources as it permits observation of the condition, distribution and abundance of benthic habitats in a continuous stretch of the coastal environment. Estimates of percentage distribution of coral reefs and associated benthos observed within the tow stations are recorded in accordance with standard categories to document distribution of coral life forms and the nature of benthic substrate. The collective picture generated can show a fairly accurate description of the overall morphology of the coastal area under study. The manta tow surveys also enable the identification of the location of seagrass meadows, if present in the area. In areas where significant coral reefs occur, results from a manta tow survey are used to pinpoint the locations of ideal stations where more detailed underwater coral reef characterization employing line transects are undertaken. Two manta tow pathways were conducted in the mouth inner Carrascal Bay with a total of thirty-two (32) benthic observation pathways. The first twenty-two (22) tows covered the fringing reef in the Adlay MPA where most of the corals in inner Carrascal Bay are located. The Adlay MPA and its fringing reef are about 2.5 km from Adlay Barangay proper. The second set of ten (10) tows was conducted in the Alingating Daku Shoal, a shoal in the mouth of the bay about 2 km from the Barangay proper. Altogether, the manta tow pathways covered a stretch of coastal waters approximately 5.2 km in the coastal impact area of the project (**Table 2.2.16**; **Figure 2.2.15**; **Plate 2.2.7**).

The categories utilized for classifying coral cover observed in manta tows follow standard ratings used for live coral distribution, i.e., 76-100% live coral cover = Excellent; 51-75% coverage live coral cover = Good, 26-50% coverage live coral cover = Fair, and 0-25% coverage live coral cover = Poor coral cover.

Table 2.2.16: Distance Covered by Manta Tow Surveys Across Carrascal Bay during Marine Ecology Baseline Assessment; March 2021

Track Segment ID	Approximate Distance (m)	Track Segment ID	Approximate Distance (m)
S00a-T01	171	T16-T17	140
T01-T02	151	T17-T18	150
T02-T03	153	T18-T19	197
T03-T04	153	T19-T20	200
T04-T05	137	T20-T21	227
T05-T06	145	T21-T22	218
T06-T07	136	S00b-T23	148
T07-T08	122	T23-T24	133
T08-T09	142	T24-T25	150
T09-T10	151	T25-T26	131
T10-T11	152	T26-T27	129
T11-T12	168	T27-T28	170
T12-T13	182	T28-T29	156
T13-T14	168	T29-T30	165
T14-T15	146	T30-T31	193
T15-T16	271	T31-T32	155
Leg 1 (S00a-T22) Length = 3.680 km			
Leg 2 (S00b-T32) Length = 1.530 km			
Accumulated Distance Covered = 5.210 km			

Figure 2.2.15: Manta Tow Pathways Surveyed during Marine Ecology Assessment; 03-05 March 2021

Plate 2.2.7: Manta Tow Being Conducted in the Coastal Impact Area during Marine Ecology Baseline Assessment; March 2021

The fringing reef comprised of live and dead corals with algae in Adlay MPA and Alingating shoal was the focus of the manta tow pathways. The Alingating reef is a narrow coral strip measuring about 2 ha. The thirty-two (32) manta tows conducted in the Carrascal Bay started in the outer shelf and ending in the nearshore area covering a linear distance of about 5.2 km and a breadth of 100 to 150 m of coastal benthic corridor revealed the dominance of mud and sandy substrate in the inner bay of the coastal impact area of the project. While corals were seen in most pathways, these were comprised of low live hard coral cover (LHC) and dead corals were dominant. The inner bay is dominated by sand and muddy substrate with patches live corals and mostly dead corals. Heavy silt and sediment loads are ubiquitous and the remaining live hard corals are vividly stressed, particularly in the Alingating reef where heavy silt and sediment blanket have led to the collapse of fragile branching corals (**Plate 2.2.8**). Broken corals in the same area – now reduced to coral rubble – seem to have been caused by scraping. All thirty-two (32) manta tow benthic observations recorded low live coral cover ranging from 5 to 30% LHC (**Table 2.2.17**). Only one (1) station contained good live coral of 50% LHC comprised mostly of resilient massive *Porites spp*, all of which were located in the slope of the Adlay MPA. The fringing reef in Alingating shoal hosted poor coral cover of mostly between 5 to 10% LHC. The lone 50% LHC in the reef crest encountered in Manta Tow station T10-T11 in the Adlay MPA was dominated almost exclusively by massive *Porites spp.* Dead corals and dead coral with algae ranged from 20 to 95% in 31 stations while sandy substrate was found in 30 tow pathways. This is indicative of the dominance of sandy substrate across the surveyed area. Across all the stations, the average live coral cover was catalogued at 13.6%, pulled down by the presence of dead coral corals (DCA), dead corals (DC) and rubble (R) in all stations totaling 58% and the presence of sandy substrate recorded at 28% across the survey pathway (**Table 2.2.17** and **Figure 2.2.16**). A map of the highlights of 32 manta tow findings is displayed as **Figure 2.2.17** and **Figure 2.2.18**.

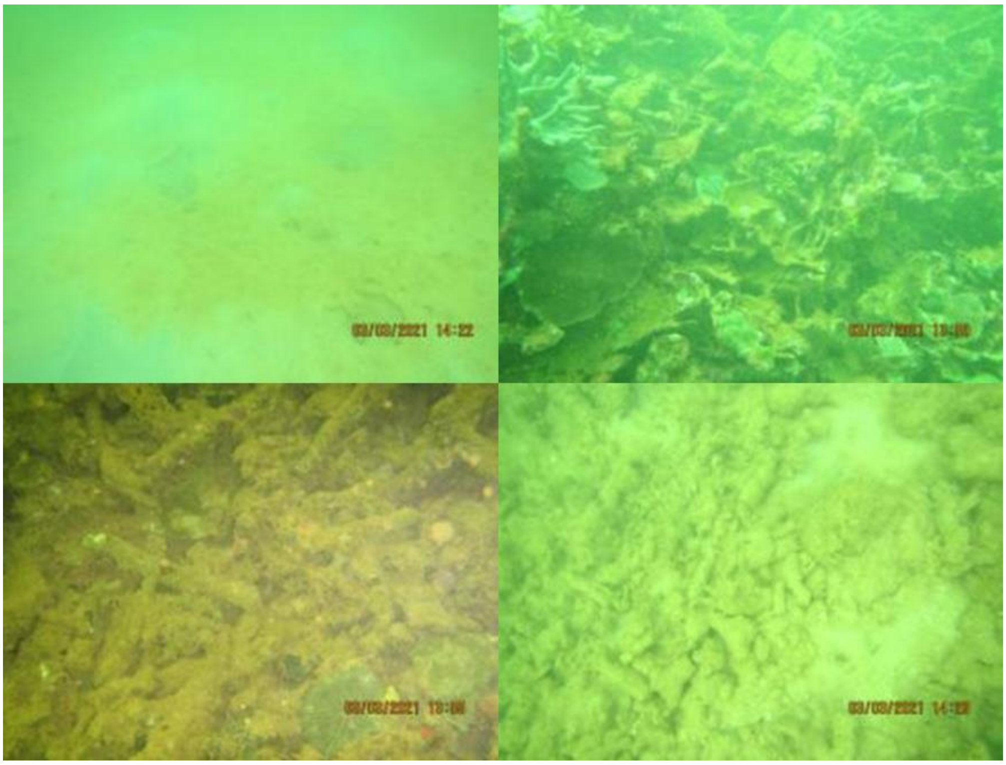


Plate 2.2.8: Sandy Substrate and Broken Dead Corals Enveloped in Silt in the Alingating Reef (top photos); Massive and Tabulate Live Hard Corals (bottom photos) in the Slope of the Adlay MPA; 03-05 March 2021

Table 2.2.17: Results of Thirty-Two Manta Tows for Coral and Benthic Substrate Profiling; March 2021

Tow Coverage	Location [DecDeg]	LHC	SC	DC	DCA	CR	S	Remarks
S00a	N 09.421591° E 125.934978°	-	-	-	-	-	-	**Start of Tow for Leg 1**
S00a-T01	N 09.420969° E 125.933553°	5	0	60	0	0	35	Within Adlay MPA, Ludguron Island
T01-T02	N 09.420393° E 125.932315°	10	0	70	0	20	0	Within Adlay MPA, Ludguron Island
T02-T03	N 09.420047° E 125.930959°	10	0	60	0	0	30	Within Adlay MPA, Ludguron Island
T03-T04	N 09.419586° E 125.929651°	10	0	0	30	0	60	Within Adlay MPA, Ludguron Island
T04-T05	N 09.420485° E 125.928787°	15	0	0	40	0	45	Within Adlay MPA, Ludguron Island
T05-T06	N 09.421753° E 125.928483°	30	0	50	0	20	0	Associated Eel seagrass and a school of surgeonfishes observed within Adlay MPA
T06-T07	N 09.422951° E 125.928203°	15	0	0	45	0	40	Within Adlay MPA, Ludguron Island
T07-T08	N 09.423965° E 125.927735°	30	0	0	30	20	20	School of *Pterocaseio pisang* was observed within Adlay MPA, Ludguron Island
T08-T09	N 09.423689° E 125.926474°	5	0	0	45	50	0	Within Adlay MPA, Ludguron Island
T09-T10	N 09.422513° E 125.925773°	15	0	0	40	15	30	Within Adlay MPA, Ludguron Island
T10-T11	N 09.421499° E 125.924838°	50	0	0	5	0	45	Dominated by massive corals within Adlay MPA, Ludguron Island;

Tow Coverage	Location [DecDeg]	LHC	SC	DC	DCA	CR	S	Remarks
T11-T12	N 09.420739° E 125.923507°	20	0	0	0	20	60	Within Adlay MPA, Ludguron Island
T12-T13	N 09.421592° E 125.922082°	5	0	0	80	0	15	Within Adlay MPA, Ludguron Island
T13-T14	N 09.421131° E 125.920633°	20	0	0	40	0	40	Within Adlay MPA, Ludguron Island; some massive corals blanketed in silt.
T14-T15	N 09.420693° E 125.919371°	20	0	0	20	0	60	Within Adlay MPA, Ludguron Island; massive corals blanketed in silt.
T15-T16	N 09.421707° E 125.919395°	15	0	0	40	0	45	Dominated by silted massive corals within Adlay MPA, Ludguron Island
T16-T17	N 09.422790° E 125.920049°	20	0	0	20	0	60	Dominated by silted massive corals within Adlay MPA, Ludguron Island; massive corals blanketed with silt.
T17-T18	N 09.423873° E 125.919231°	20	0	0	70	0	10	Within Adlay MPA, Ludguron Island; massive corals blanketed with silt.
T18-T19	N 09.423205° E 125.917572°	15	0	0	60	0	25	Within Adlay MPA, Ludguron Island; massive corals blanketed with silt.
T19-T20	N 09.422974° E 125.915773°	10	0	0	50	0	40	Within Adlay MPA, Ludguron Island; massive corals blanketed in silt.
T20-T21	N 09.422467° E 125.913764°	20	0	0	60	0	20	Dominated by silted massive corals with a school of parrotfish observed within Adlay MPA, Ludguron Island
T21-T22	N 09.421223° E 125.912222°	5	0	0	95	0	0	Dominant Dead Corals with Algae; **end of Leg 1**
S00b	N 09.434383° E 125.916521°	-	-	-	-	-	-	**Start of Tow for Leg 2**
S00b-T23	N 09.433046° E 125.916591°	10	0	0	85	0	5	Along Alingating Daku Shoal, Barangay Adlay; heavy silt load in dead corals; widespread coral rubble and dead standing corals blanketed with silt
T23-T24	N 09.431871° E 125.916825°	5	5	60	0	0	30	Murky surface water *(approx 1.0 meter visibility)* along Alingating Daku Shoal, Barangay Adlay; heavy silt load in dead corals and rubble
T24-T25	N 09.431709° E 125.918180°	5	0	0	65	0	30	Along Alingating Daku Shoal, Barangay Adlay; coral rubble with heavy blanket of silt ; heavy silt load in dead corals and rubble
T25-T26	N 09.431318° E 125.919301°	5	5	0	60	0	30	Along Alingating Daku Shoal, Barangay Adlay; heavy silt load in dead corals and rubble
T26-T27	N 09.430188° E 125.919021°	10	5	10	60	0	15	Along Alingating Daku Shoal, Barangay Adlay; heavy silt load in dead corals; widespread coral rubble and dead standing corals blanketed with silt
T27-T28	N 09.428944° E 125.918110°	5	0	30	0	5	60	Dominated by staghorn corals along Alingating Daku Shoal, Barangay Adlay; widespread dead standing staghorn corals with silt
T28-T29	N 09.427907° E 125.917152°	10	0	30	40	20	0	Along Alingating Daku Shoal, Barangay Adlay; heavy silt load in dead corals; widespread coral rubble and dead standing corals blanketed with silt
T29-T30	N 09.427123° E 125.915867°	10	0	30	20	10	30	Dominated by foliose corals along Alingating Daku Shoal, Barangay Adlay; heavy silt load in dead corals; widespread coral rubble and dead standing corals blanketed with silt
T30-T31	N 09.426385° E 125.914278°	5	0	5	40	30	20	Along Alingating Daku Shoal, Barangay Adlay; heavy silt load in dead corals; widespread coral rubble and dead standing corals blanketed with silt

Tow Coverage	Location [DecDeg]	LHC	SC	DC	DCA	CR	S	Remarks
T31-T32	N 09.425809° E 125.912993°	5	0	0	95	0	0	Along Alingating Daku Shoal, Barangay Adlay; **end of Leg 2**
Average Reef and Substrate Composition		**13.6**	**0.5**	**12.7**	**38.6**	**6.6**	**28.0**	

Site name:	Coastal waters of Carrascal Bay approx 7km east offshore from the proposed 4DVDI MPSA Site; Carrascal, Surigao Del Sur	**Survey Team:**
Time / Date:	0935H-1323H / 03 March 2021	1. Benjamin Francisco 2. Victor Pantaleon 3. Ronald Pocon 4. Ernie Fontamillas
Tow Speed:	3.0 kmh (ave)	
Visibility:	Turbid waters varying from 1-5m visibility	
Weather:	Cloudy and partly Overcast	
Wave:	Mild wave action from approx. ± 10cm to ± 15cm rolling wave crests	
Current:	Mild to lightly strong	
Tide:	Lowering from 1.45m to 0.07m as ref from Buenavista, General Island Tidal Station (WXTIDE32 App)	
Water Temp:	Varying from approx. ± 28°C	
Wind:	Beaufort Scale #3	
Cloud Type(s):	Cumulus turning to Nimbostratus and Cumulonimbus by midday	

- Tow area coverage are expressed in Decimal Degrees WCS notation in reference to WGS84 Map Datum
- Reef and Substrate composition are expressed in (%) and described as follows:
  - Live hard coral (LHC) - coverage of stony or hard corals on the bottom or part of the bottom
  - Live soft coral - (SC) - coverage of soft corals attached to the bottom
  - Dead coral (DC) - recently dead coral still attached and recognizable at the bottom in original upright position, color usually white with no living tissue
  - Dead coral with algae (DCA) - corallites still visible, skeletal structure can still be seen but algae dominate the structure (often appears greenish to brownish)
  - Coral rubble/rock (CR) - loose broken fragments of stony corals, consolidated hard bottom or large blocks of hard reef materials not attached or easily moved around
  - Sand/silt (S)

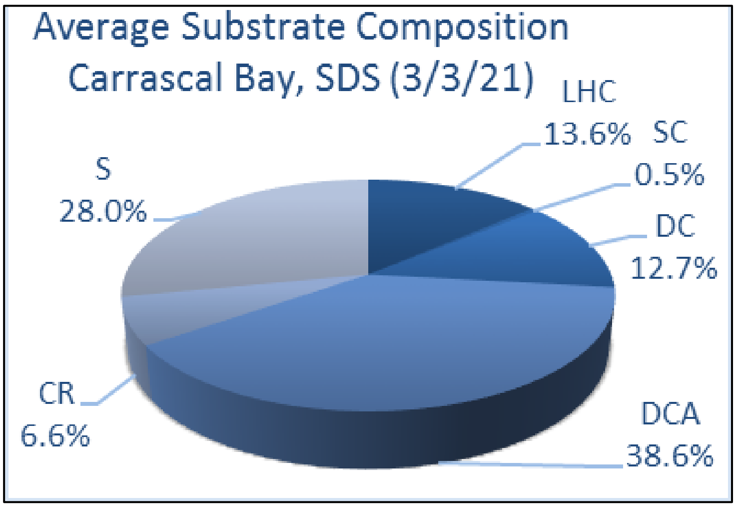


Figure 2.2.16: Mean Coral and Benthic Substrate Readings from 32 Manta Tows Surveyed during Marine Ecology Baseline Assessment; 03-05 March 2021

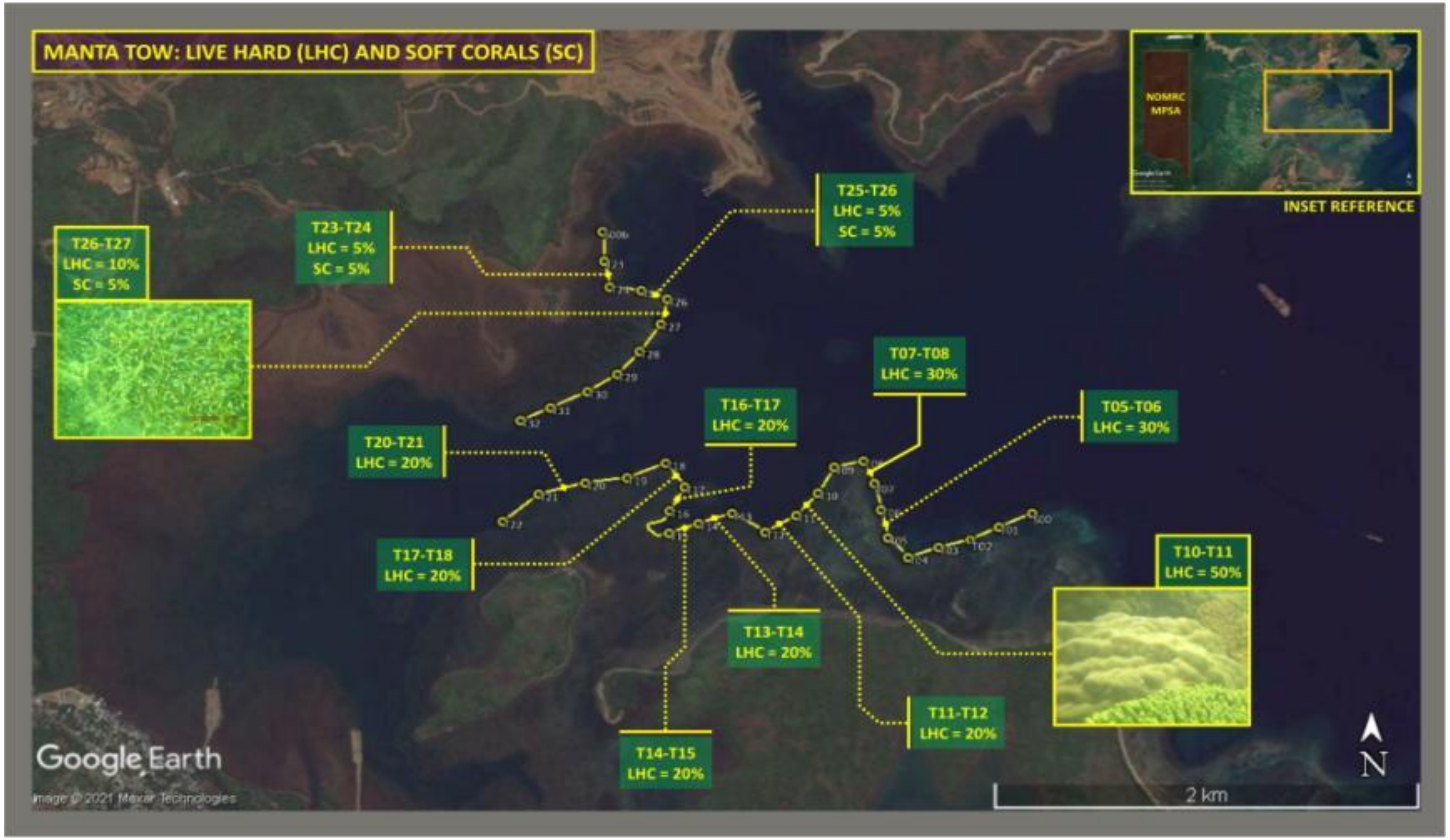


Figure 2.2.17: Map showing Live Hard Cover Findings from 32 Manta Tow Benthic Surveys; March 2021

Note; Combined, the DC and DCA values were registered at a mean of 51.3%.

Figure 2.2.18: Map showing DCA Results of 32 Manta Tow Benthic Surveys; 03-05 March 2021

2.2.4.1.2 Corals – Detailed Coral Assessment in Two Line Intercept Transects

Assessment of coral life forms, reef abiotics and benthic substrate composition was undertaken employing the line intercept transect (LIT) method (**Plate 2.2.9**). Two (2) LIT stations were surveyed for detailed coral profiling. The first LIT was laid out in the Alingating Daku shoal and the second in the slope of the Adlay MPA. Both these reefs are located in the mouth of inner Carrascal Bay about 2 km from Barangay Adlay proper. The objective is to characterize reef habitat conditions by estimating the cover of various coral life forms utilizing standard categories along the transect line. Data generated from line-intercept method for coral reef assessment provides more accurate information on percentage of live coral cover as well as species distribution that can be ultimately used for comparative evaluation if the same survey stations are monitored in the future. The categories utilized for classifying coral cover follow standard ratings used for live coral distribution, i.e., 76-100% live coral cover = Excellent; 51-75% coverage live coral cover = Good, 26-50% coverage live coral cover = Fair, and 0-25% coverage live coral cover = Poor coral cover (Gomez, et al.,1981).

The station coordinates are listed in **Table 2.2.18** and depicted in **Figure 2.2.19**.

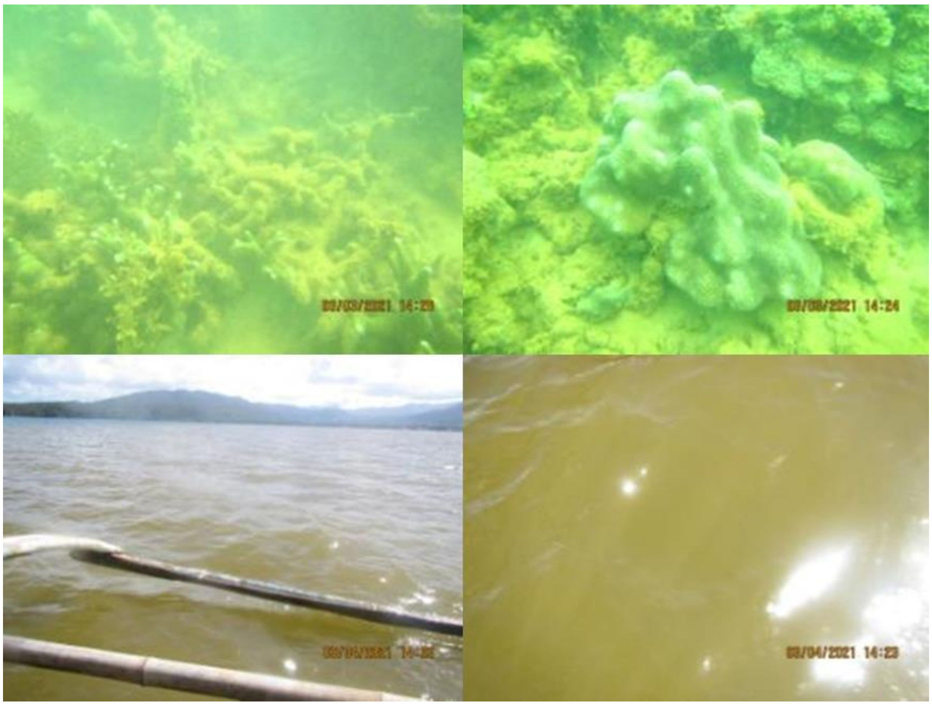
Table 2.2.18: Coordinates of Survey Stations for Coral Diversity; 03-05 March 2021

Station	Latitude	Longitude	Remarks
LIT1	N 09.428140°	E 125.918080°	Located in the crest of Alingating Daku shoal which is a fringing reef isolated from the northern coastline of Brgy. Adlay by a deep channel, 1.5 km from the shoreline; 6.3 to 8 meters of water (low tide).
LIT2	N 09.420630°	E 125.923700°	Located inside the slope of the fringing reef in Adlay MPA near Ludgoron Island about 1.6 km from the shoreline of Barangay Adlay; 2-7 m of water (low tide).

Plate 2.2.9: Coral Survey Being Undertaken During Marine Ecology Baseline Assessment; 03-05 March 2021

Figure 2.2.19: Location of LIT Stations; 03-05 March 2021

The corals in line intercept transect station 1 (Alingating shoal) was catalogued at 16%, categorized as "Poor". Widespread coral demise is vivid, caused by heavy silt and sediment blanketing across the reef. Carpets of broken corals dominated the reef, with sporadic live staghorn corals remaining at 12.8% of the survey corridor. Massive corals, also vividly stressed from sediment loading, were catalogued at 0.4 %. In view of this, dead corals with algae (44%), coral rubble (32.10%) and dead corals (7.8) dominated the reef (**Table 2.2.19**; **Figure 2.2.20**). All in all, dead corals and rubble totaled 84% of the reef. Silt intrusion is coming largely from the Kay-ongan River and to a lesser extent, Nasipit River. At the time of the survey, the brown-colored outflows have spread over half of inner Carrascal bay (**Plate 2.2.10**).



Note: Lower photos show sediment-laden seawater that have reached the Alingating shoal

Plate 2.2.10: Dead and Broken Corals with Algae in Coral LIT Station 1 (Alingating Daku shoal); 03-05 March 2021

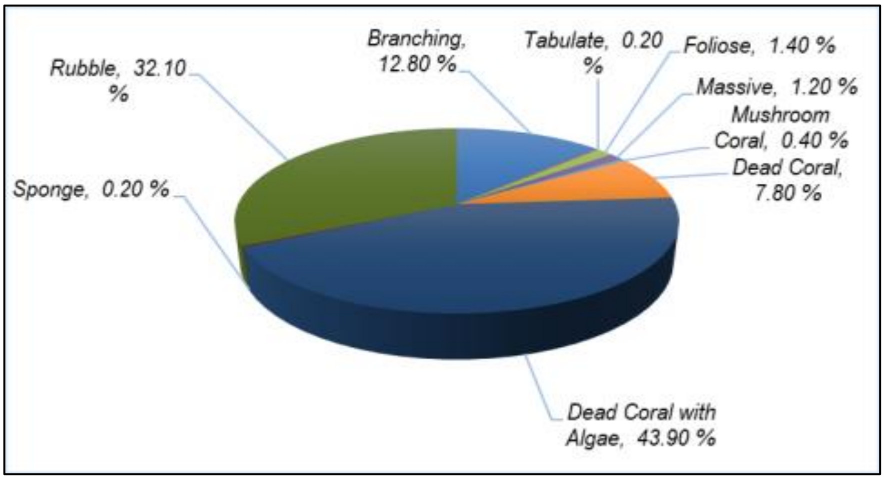


Figure 2.2.20: Distribution (in % of Total Coral Cover) of Coral Lifeforms in LIT Station 1 (Alingating Daku Shoal); March 2021

In Station 2 (Adlay MPA), located about 0.5 km south of Station 1, the average live hard coral cover was documented at 58.2%, ("Good" condition), with massive corals almost exclusively dominating the community, accounting for 53% of the colonies (**Table 2.2.19** and **Figure 2.2.21**). Dead corals with algae comprised 38.8%. The corals in the slope of the Adlay MPA, as they are located beside a deep channel, have somehow survived massive silt and sediment blanketing in portions of Carrascal Bay.

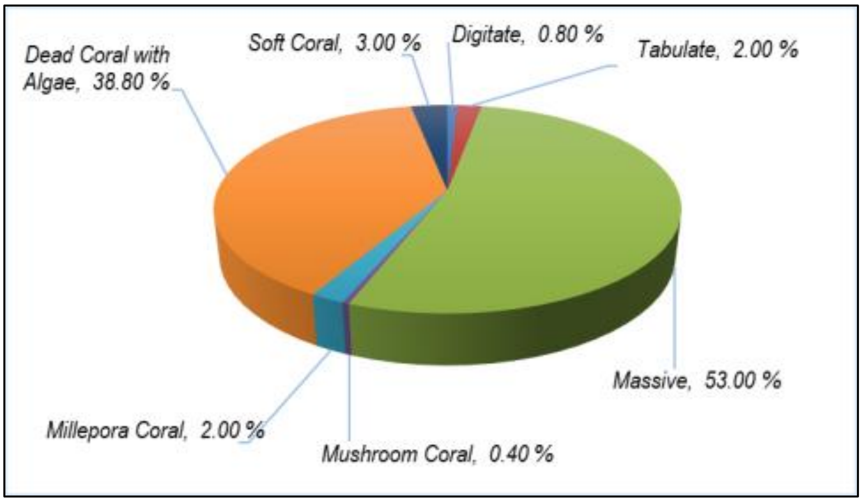


Figure 2.2.21: Distribution (in % of Total Coral Cover) of coral Lifeforms in LIT Station 2 (Adlay MPA); March 2021

Table 2.2.19: Distribution of Coral Cover (in Average Percentage of Total Survey Area) of the Different Coral Lifeform Categories across Two LIT Transects; March 2021

Life Categories		**Code**	**Distribution per Transect** *(In %)*	
			1	**2**
Acropora	*Branching*	*ACB*	12.80	
	Digitate	*ACD*		0.80
	Tabulate	*ACT*	0.20	2.00
Non-Acropora	*Foliose*	*CF*	1.40	
	Massive	*CM*	1.20	53.00
	Mushroom Coral	*CMR*	0.40	0.40
	Millepora Coral	*CME*		2.00
AVERAGE % LIVE HARD CORAL COVER			**16.00** ***(Poor)***	**58.20** ***(Good)***
Dead Coral		*DC*	7.80	
Dead Coral with Algae		*DCA*	43.90	38.80
Other Fauna	*Soft Coral*	*SC*		3.00
	Sponge	*SP*	0.20	
	Rubble	*R*	32.10	
Name of Site: Barangay Adlay			**Municipality & Province:** Carrascal, Surigao del Sur	
Date: March 3 - 5, 2021			**Observers:** Victor L. Pantaleon & Ronald T. Pocon	
Location:				**Depth** (in meter):
Survey Station No.: 1 *Start: 125.91808^0 E, 09.42814^0 N; End: 125.91771^0 E, 09.42804^0 N*				4 - 6 meters
Survey Station No.: 2 *Start: 125.92370^0 E, 09.42063^0 N; End: 125.92407^0 E, 09.42080^0 N*				2 - 3 meters

Note: Status Category: Poor = 0 - 24.9; Fair = 25 - 49.9%; Good = 50 - 74.9%; Excellent = 75 - 100% (Gomez et al. 1981)

Across the two line intercept stations for detailed coral assessment, the average live coral cover was documented at 37.10% which is categorized as "Fair" coral cover under standard rating system for corals (**Table 2.2.20**). It is interesting to highlight that the fair coral cover was almost exclusively the result of good coral cover in the Adlay MPA. The diversity of coral species – with 37 species observed - is presented in **Table 2.2.21**. Across the two survey corridors, massive Porites colonies dominated the reefs, while branching Acropora corals – among others, Acropora formosa (staghorn corals) and Seriatopora hystrix (bird's nest branching corals) were found in patches, most of which were stressed with sediment suffocation. The branching corals accounted for only 6.4 of the coral community while massive corals comprised 27.1 % across the stations. Tabulate corals - colonies of Acropora indonesia and Acropora donei, among others, foliose (Montipora sp), mushroom (Fungia sp) and fire (Millepora) corals – were also present, altogether occupying 3.7% of the community across the two stations (**Figure 2.2.22**). Soft corals accounted for 1.50% of the population. Coral rubble comprised 16%. Combined, dead corals with algae, dead standing corals and coral rubble was catalogued at a high 60% across the two surveyed areas.

Table 2.2.20: Distribution of Coral Cover (in Average Percentage of Total Survey Area) of the Different Coral Lifeform Categories across Two (2) LIT; 03-04 March 2021

Lifeform Categories		Code	Average Percentage Cover *(In %)*
Acropora	*Branching*	*ACB*	**6.40**
	Digitate	*ACD*	**0.40**
	Tabulate	*ACT*	**1.10**
Non-Acropora	*Foliose*	*CF*	**0.70**
	Massive	*CM*	**27.10**
	Mushroom Coral	*CMR*	**0.40**
	Millepora Coral	*CME*	**1.00**
AVERAGE PERCENT LIVE HARD CORAL (LHC) COVER			***37.10 Fair Condition***
Dead Coral		*DC*	**3.90**
Dead Coral with Algae		*DCA*	**41.35**
Other Fauna	*Soft Coral*	*SC*	**1.50**
	Sponge	*SP*	**0.10**
	Rubble	*R*	**16.05**

Note: Status Category: Poor = 0 - 24.9; Fair = 25 - 49.9%; Good = 50 - 74.9%; Excellent = 75 - 100% (Gomez et al. 1981)

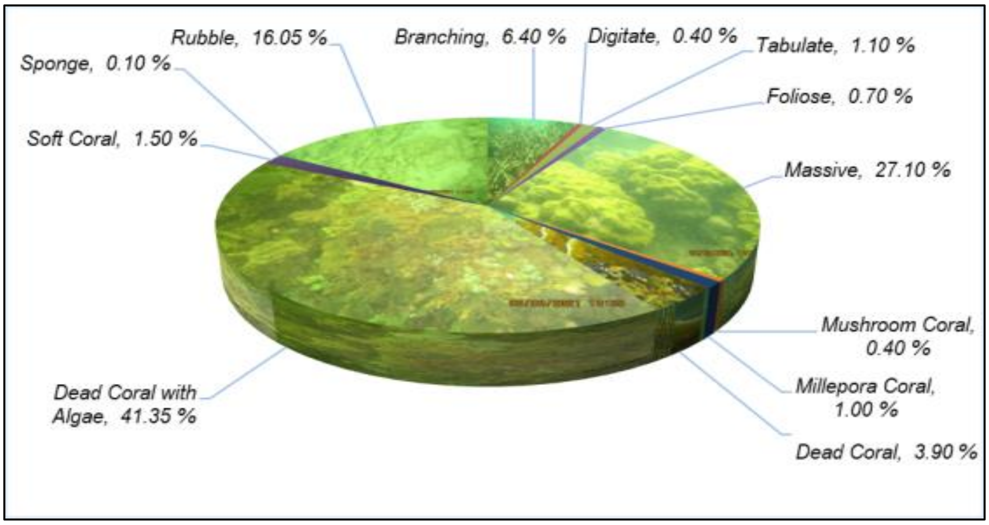


Figure 2.2.22: Mean Distribution of Coral Life Forms Across two (2) LIT Stations

Table 2.2.21: Some Coral Species Encountered in Two (2) LIT Stations

Massive	Branching	Digitate, Encrusting, Sub-Massive, Tabulate, Mushroom, Foliose and Others Fauna (Hydroids & Sponge)
Diploria clivosa	*Acropora formosa (staghorn)*	*Acropora humilis*
Euphyllia glabrescens	*Acropora florida*	*Acropora digitifera*
Favia speciosa	*Acropora inermis*	*Montipora hirsute*
Pavona venosa	*Acropora nobilis*	*Montipora samarensis*
Physogyra lichtensteini	*Acropora palifera*	*Montipora cactus*
Porites astreoides	*Acropora robusta*	*Acropora clathrata*
Porites densa	*Montipora digitata*	*Acropora donei*
Porites lobata	*Montipora hirsute*	*Acropora indonesia*
Porites lutea	*Montipora porites*	*Acropora hyacinthus*
Porites solida	*Pocillopora elegans*	*Fungia danai*
	Porites nigrescens	*Fungia moluccensis*
	Seriatopora hystrix	*Millepora platyphylla*
		Millepora alcicornis
		Clavularia viridis

Of this list of coral species existing in the project site, the IUCN lists eleven (11) coral species as *Near Threatened, i.e, - Porites lobata, Porites lutea, Acropora florida, Acropora formosa, Acropora robusta, Montipora porites, Acropora digitifera, Acropora hyacinthus, Seriatopora hystix, Acropora humilis, Montipora hirsute;* while seven (7) species - *Acropora robusta, Acropora donei, Acropora indonesia, Montipora samarensis, Pavona venosa, Pocillopora elegans and Porites nigrescens* are listed as *Vulnerable*. The rest are categorized as *Least Concern.*

Plate 2.2.11: Some Coral Species Encountered in LIT Station 2

The highlights of the coral LIT survey are presented in a map in **Figure 2.2.23**.

Figure 2.2.23: Results from Line Intercept Survey for Corals and Benthic Life Form Distribution in Two (2) Stations; March,2021

2.2.4.2 Associated Reef Fish Communities

Fish species richness and abundance of reef-associated species of fish was estimated in the LIT station through standard fish visual census (FVC). The conduct of FVC is designed to document a fairly accurate picture of demersal fish population along a 10-m belt following a 50-m transect laid over representative coral reef stations species diversity. In this case high values for these principal variables in a 500-m survey corridor can indicate the overall ecological condition of a reef area and can give a glimpse of ecosystem function and integrity. Collectively, the results of coral reef assessments and fish visual census are used as reference points for comparative monitoring of changes in spatial distribution and diversity of benthic life forms in periodic environmental impact monitoring – before and after the project is operating. FVC surveys document mostly demersal, reef-associated species of fish that normally indicates the robustness of a coral reef ecosystem. In healthy reefs, the fish species diversity may include both commercially important fish (e.g., Groupers, Snappers) and reef-dependent species (Angelfishes and Butterfly fishes). FVC was conducted in the same LIT station 2 but no longer in the Alingating shoal (LIT station 1) due to scarce reef fish population brought about by the low live coral cover and the presence of widespread coral rubble.

Fish species encountered in the FVC transects are categorized as target, major or indicator species based on categories recommended in *FishBase* (2004). Target species are economically important food fish that are normally sought by fishers for trade of for food. In reef areas, such demersal species may include high value groupers (*Ephinephalidae*), snappers (*Lutjanidae*), jacks (*Carangidae*) and some species of surgeons (*Acanthuridae*). Fish that belong to the major fish category are considered to be ecologically important because they occupy unique niches and sometimes symbiotic relationships in the coral reef ecosystem. Many of these species are represented by members of the damselfishes (*Pomacentridae*) and wrasses (*Labridae*). Indicator species are coral-feeders whose presence, variety and abundance in a reef area may give an indication of the robustness and diversity of corals present in the reef. These are mostly comprised of the magnificently-colored butterflyfishes (*Chaetodontidae*), species of Angelfishes and the lone damsel species popularly known as *Moorish Idol*.

The FVC station coordinates are shown in **Table 2.2.22**; location of the station is shown in **Figure 2.2.24**.

Table 2.2.22: Coordinates of Fish Visual Census Stations for Fish Species Richness and Abundance; 03-05 March 2021.

Station	Latitude	Longitude	Remarks
FVC2	N 09.428140°	E 125.918080°	Same location as LIT2 with a depth of 2-6 m. FVC station covered 10 x 50 m (500 m^2) of survey corridor. Census covered all species of fish encountered in the belt. Recorded 52 individuals within a 500m^2 transect area with 19 species distributed in 9 family taxa. Most abundant were *Chromis alpha* with 10 individuals each; surveyed at a depth of 7-10m
FVC2	N 09.420630°	E 125.923700°	Same location as LIT 1. Recorded 64 individuals within a 500m^2 transect area with 11 species distributed in 6 family taxa. Most abundant were *Parupeneus barberinus* and *Amblyglyphidodon curacao* both with 15 individuals each; surveyed at a depth of 7-10m

Figure 2.2.24: Map showing the Location of Stations Surveyed for Fish Species Richness and Abundance; 03-05 March 2021

Fish visual census in the two stations counted a total of 116 individuals with 28 species in 17 family taxa (**Table 2.2.23**; **Figure 2.2.25**). The abundance recorded is poor, reflecting the low coral cover in Alngating reef which accounted for 44% of the total abundance across two LIT stations. The fish community is dominated by typically resilient species of damselfishes (Labridae) with 39 individuals and wrasses (Labride) with 22 individuals. Target species were catalogued at 17 individuals (**Figure 2.2.26**), with emperors, snappers and juvenile groupers encountered in LIT station 1.

There were two (2) indicator butterfly fish species. Mean fish density is less than 1 individual per square meter (**Figure 2.2.27**). Fish biomass is about 1 kg/500m^2 (**Figure 2.2.28**), indicating few fish abundance dominated mostly by juvenile fishes.

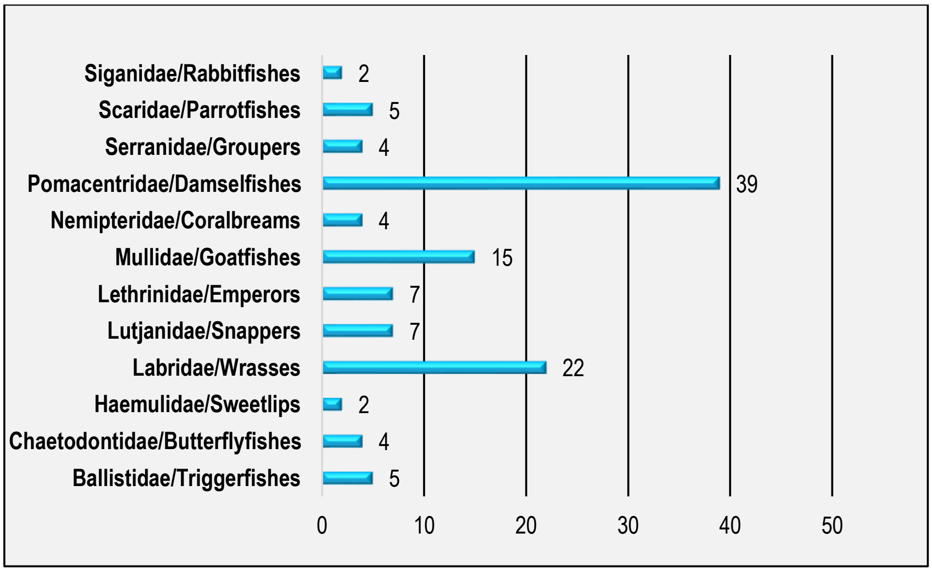


Figure 2.2.25: Relative Abundance of Fish Species across Two FVC Transect Stations; March 2021

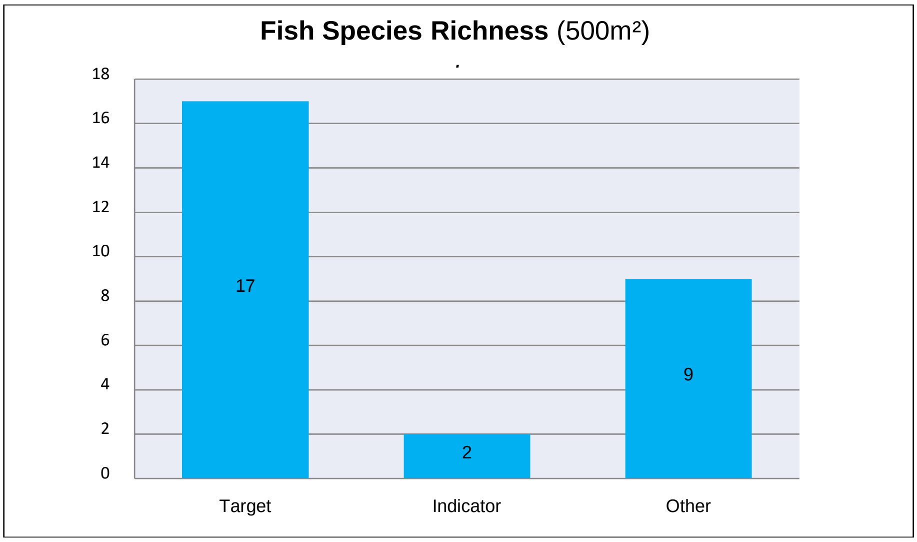


Figure 2.2.26: Fish Species Diversity by Category across Two FVC Transect Stations; March 2021

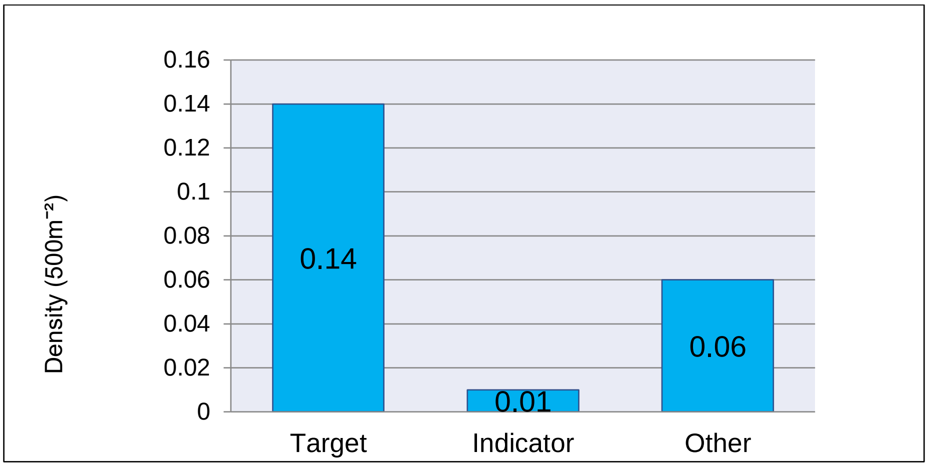


Figure 2.2.27: Fish Density by Category of Fish Species across Two FVC Transect Stations; March 2021

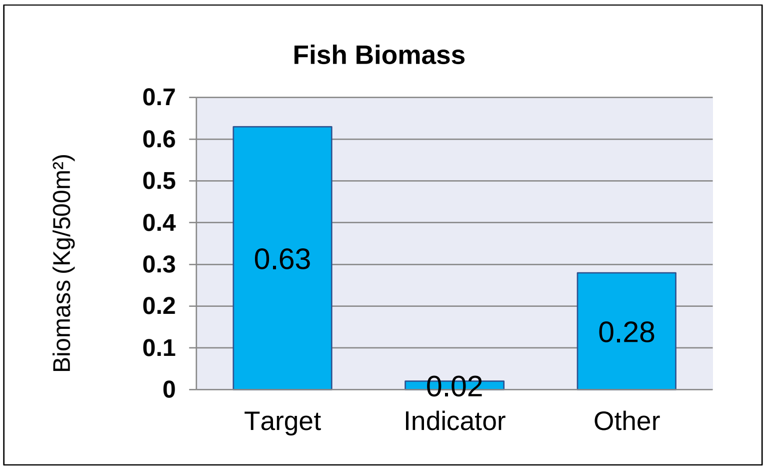


Figure 2.2.28: Mean Fish Biomass by Category of Fish Species across Two FVC Transect Stations; March 2021

Key informants claim that the Adlay MPA and the extensive fringing reel in the vicinity of Ludguron Island 1.5 km from the shoreline used to support robust fisheries in nearshore fishing grounds. Gill nets are the main fishing gear, targeting pelagic species such as big eye scad (Matangbaka), hairtail (Espada) and trevallies (Talakitok). Demersal fish species, caught through hook and line around the MPA, consist mainly of snappers (Lutjanidae), emperors (Letrinidae) and trevallies (Carangidae). However, fishers alleged that fisheries catch rates have declined significantly presumably due to overfishing and the turbid coastal waters caused by silt streams from upland areas and discharge into the bay through river systems. No gill netting was encountered during the survey. None of the species catalogued in the fish visual census and coral survey are endemic. The finfish species, however, are of important commercial value as foodfish, particularly target fish species which are experiencing population declines due to overfishing and loss of habitats.

Table 2.2.23: Fish Abundance and Species Richness in Two (2) Fish Visual Census (FVC) Stations; March 2021

Family	Scientific Name	Common Name	Local Name	Station 1		Station 2		Total No. of Individuals
				No. of Indi	Size (cm)	No. of Indi	Size (cm)	
Balistidae	*Pseudobalistes flavimarginatus*	Yellowmargin triggerfish	Pakol	1	10			**1**
Balistidae	*Balistoides viridescens*	Titan triggerfish	Pakol	1	8			**1**
Balistidae	*Balistapus undulatus*	Oranged-lined triggerfish	Pakol	3	12			**3**
Chaetodontidae	*Chaetodon kleinii*	Sunburst butterflyfish	Paru-paro			2	5	**2**
Chaetodontidae	*Chaetodon baronessa*	Eastern triangular butterflyfish	Paru-paro			2	8	**2**
Haemulidae	*Plectorhincus macrospilus*	Largespot sweetlips	Lipti	1	4	1	10	**2**
Labridae	*Cheilio inermis*	Cigar wrasse	Surip	2	10			**2**
Labridae	*Choerodon anchorago*	Oranged-dotted tuskfish	Mul-mol			6	8	**6**
Labridae	*Thalassoma lunare*	Moon wrasse	Bankilan/Bunak	4	10	3	6	**7**
Labridae	*Thalassoma Hardwicke*	Sixbar wrasse	Labayan	5	8			**5**
Labridae	*Cheilinus trilobatus*	Tripletail wrasse	Labayan	1	8			**1**
Labridae	*Cheilinus fasciatus*	Banded splendor	Ipospadi			1	10	**1**
Lethrinidae	*Lethrinus xanthochilus*	Yellow-lip Emperor	Dugso	4	8			**4**
Lethrinidae	*Lethrinus lentjan*	Pink ear emperor	Katambak	3	10			**3**
Lutjanidae	*Lutjanus rufolineatus*	Yellow-lined snapper	Mangagat	2	12			**2**
Lutjanidae	*Lutjanus biguttatus*	Two-spot banded snapper	Labongan	1	8			**1**
Lutjanidae	*Lutjanus decussatus*	Checkered snapper	Dolesan	3	6			**3**
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper	Mayamaya	1	10			**1**
Mullidae	*Parupeneus barberinus*	Dash-and-dot goatfish	Saramulyete			15	5	**15**
Nemipteridae	*Scolopsis ciliatus*	Whitestreak monocle bream	Silay	4	6			**4**
Pomacentridae	*Chromis alpha*	Yellow-speckled chromis	Palata	10	6			**10**
Pomacentridae	*Amphiprion frenatus*	Tomato anemonefish	Bantay botbot			4	8	**4**
Pomacentridae	*Chromis analis*	Yellow chromis	Palata			10	3	**10**
Pomacentridae	*Amblyglyphidodon curacao*	Staghorn damsel	Palata			15	6	**15**
Serranidae	*Cephalopholis boenak*	Brown-barred grouper	Lapu-lapo, Gaot	3	6			**3**
Serranidae	*Epinephelus ergastularius*	Sevenbar grouper	Dulit	1	8			**1**
Scaridae	*Scarus dimidiatus*	Yellow-barred parrotfish	Loro/mol-mol			5	10	**5**
Siganidae	*Siganus vulpinus*	Foxface rabbitfish	Samaral	2	8			**2**
Total No. of individuals per transect (500m²)				**52**		**64**		**116**
Total number of fish families							**12**	
Total number of target species							**17**	
Total number of indicators							**2**	
Total number of other species							**9**	
Total number of species							**28**	

Figure 2.2.29: Highlights of Fish Visual Census in Two Stations; March 2021

2.2.4.3 Plankton Community

Species composition, abundance and density of phytoplankton and zooplankton communities were determined using a plankton net vertically lowered and towed from sub-surface depths. Shannon-Weaver Diversity/Evenness Indices and bio-assessment metrics are then derived from the results of the sampling. Identification of phytoplankton species that can enrich to become harmful algal blooms and potentially cause paralytic shellfish poisoning (PSP) was also undertaken as algal blooms normally indicate hyper-nutrient levels in the sea sometimes triggered by problems of anthropogenic origin. Samples were collected in tree (3) sampling stations spread out in the coastal impact area of the proposed project (**Plate 2.2.12**). The coordinates of the sampling stations are listed in **Table 2.2.24** and shown in a map in **Figure 2.2.30**.

Table 2.2.24: Coordinates of Plankton Community Sampling Stations; 03-05 March 2021

Station	Latitude	Longitude	Remarks
PLK1	N 09.427050°	E 125.916460°	Located in coastal waters offshore of the coastline of Bgy Adlay, about 1.5 km from the shoreline ear Alingating shoal. Dominant phytoplankton *Ceratium* sp. at 1,682 cells/L, while dominant zooplankton Copepod Nauplius and Copepodites (larval form) at 142,543 indiv/m^3
PLK2	N 09.409670°	E 125.903870°	Located near the estuary of the Nasipit River in coastal waters near the shoreline of Barangay Adlay, Carrascal. Dominant phytoplankton *Cocconeis* sp. at 4,925 cells/L, while dominant zooplankton Copepod Nauplius and Copepodites (larval form) at 68,068 indiv/m^3
PLK3	N 09.420760°	E 125.923620°	Located in the mouth of inner Carrascal Bay near Adlay MPA, 1.5 km from the shoreline. Dominant phytoplankton *Ceratium* sp. at 12,973 cells/L, while dominant zooplankton Copepod Nauplius and Copepodites (larval form) at 151,351 indiv/m^3

Plate 2.2.12: Plankton Community Sampling; 03-05 March 2021

Figure 2.2.30: Map showing the Location of Stations Surveyed for Plankton Community Diversity and Abundance; 03-05 March 2021

2.2.4.3.1 Phytoplankton

Overall, dinoflagellates dominated the phytoplankton community constituting 71% of the total counts and diatoms came second accounting 29% of the total phytoplankton abundance. Results of the analysis showed that phytoplankton density was moderately high but the diversity was generally low (<2.0) in sampling locations. It varied from 5,646 cells per liter at PLK1 to 28,228 cells per liter at PLK3. The most taxa rich station was observed station PLK1 and PLK2 with 12 while the most depauperate station was observed in station PLK3 with 11.

All the sampled stations revealed the presence of both diatoms and dinoflagellates. Blue-green algae was only observed in two stations (PLK2 and PLK3). A total of twenty-one (21) genera was recorded. Among the dinoflagellates, the armored dinoflagellate *Ceratium* spp. was the most abundant with a total recorded density of 14,734 cell per liter (36% of the total composition). It was observed at highest density in stations PLK3 at 12,973 cells per liter. This species is quite common and has a cosmopolitan distribution. Among the diatoms, the centric species *Coconeis* spp. was the most abundant with total cell density of 4,925 cells per liter (12% of the total composition). Commonly found in warm tropical waters, these diatoms provide significant influences in the overall primary productivity in such marine environments. Furthermore, these are some of the major food sources of filter- feeding shellfish, which were found along the coastal waters of the survey area. Other phytoplankton taxa with relatively relative abundance were *Prorocentrum* sp. (22%), *Protoperidinium* sp. 8%) and *Skeletonema* sp. (2%) and the rest of the phytoplankton taxa accounted of % of the total abundance.

The species identified in this sampling which is listed in IOC-UNESCO Reference List of Harmful Microalgae (Moestrup et. al 2009) were *Dinophysis* spp. and *Pseudonitzschia* spp. The *Dinophysis* species identified here as *D. caudata is* a toxic dinoflagellate capable of producing toxin associated with Diarrhetic Shellfish Poisoning (DSP) (FAO, 2004). It is a cosmopolitan species with wide distribution and also associated with red tide resulting to mass mortality of fish in countries like Gulf of Thailand and Seto Inland Sea in Japan (Okaichi 1967). In this survey however, it was recorded at low density (240 cells per liter (0.58% of the total composition). Since there was no extensive shellfish farming in the area, major negative public health and economic impact is very unlikely but should not be ruled out. Another potentially harmful phytoplankton identified during this survey is *Pseudonitzschia* spp. Some species within this genus are reported to produce toxins associated with Amnesic Shellfish Poisoning (ASP). The contribution of this genus to overall phytoplankton abundance was very low with a total density of 80 cells per liter (0.19% of the total composition). In addition, there is no confirmed incidence of ASP and DSP cased was reported in the Philippines, but it is still highly recommended to continue monitoring after the project to prevent negative public health impact brought about by possible blooms of these species in other period. *Pyrodinium bahamense* var. *compressum*, the most notorious phytoplankton species to historically cause Paralytic Shellfish Poisoning (PSP) cases and deaths from contaminating shellfish in many coastal areas in the Philippines was not observed in this survey.

Diversity Index (H) at the sampling locations showed values as low as 1.40 (site PLK2) to a as high 1.91 (site PLK1). The Evenness of index was quite similar with values ranging from 0.56 (PLK2) to 0.77 (PLK1).

A summary of the phytoplankton genera recorded in three (3) sampling stations is presented in **Table 2.2.25**.

Table 2.2.25: Phytoplankton Composition, Abundance (cells/L), Diversity and Distribution in Three Sampling Stations; March 2021

Taxa	Stations			Grand Total	Relative Abundance
	PLK1	PLK2	PLK3		
Diatoms	**801**	**6,847**	**4,204**	**11,852**	**28.68**
Amphora			280	280	0.68
Chaetoceros	120		240	360	0.87
Coconeis		4,925		4,925	11.92

Taxa	Stations			Grand Total	Relative Abundance
	PLK1	PLK2	PLK3		
Coscinodiscus	240	360	2,683	3,283	7.95
Ditylum	40		80	120	0.29
Leptocylindrus	0	320		320	0.78
Melosira	0		400	400	0.97
Pseudonitzchia	80			80	0.19
Rhizosolenia	0	120		120	0.29
Skeletonema		160	521	681	1.65
Synedra		40		40	0.10
Tabellaria		440		440	1.07
Thalassionema	240	280		521	1.26
Thalassiosira	80	200		280	0.68
Dinoflagellates	**4,845**	**601**	**24,024**	**29,469**	**71.32**
Ceratium	1,682	80	12,973	14,735	35.66
Dinophysis	80		160	240	0.58
Gonyaulax	681			681	1.65
Odontella			200	200	0.48
Prorocentrum	1,321	280	7,568	9,169	22.19
Protoperidinium	120	240	3,123	3,483	8.43
Scripsiella	961			961	2.33
Grand Total	**5,646**	**7,447**	**28,228**	**41,321**	**100**
Richness	**12**	**12**	**11**		
Evenness (J')	**0.77**	**0.56**	**0.62**		
Diversity (H')	**1.91**	**1.40**	**1.48**		

2.2.4.3.2 Zooplankton

Overall, larval forms dominated the zooplankton community which accounted 56%. Adult forms on the other hand, only accounted 44% of the total zooplankton abundance. Moreover, results of the analysis showed that density were generally high but richness and diversity was low at all the sampling locations. Zooplankton density varied from 92,092 individuals per m^3 at PLK2, to 388,388 individuals per liter at PLK3. The most taxa rich station were observed in stations PLK3 with 8 while the lowest was observed in station PLK2 with 5.

All the sampled station were mostly composed copepods, larvacean, polychaete, bivalve larvae, gastopod larvae and balanus larvae A total of nine (9) zooplankton were recorded. Among the larval forms, copepod nauplius and copepodite recorded the highest abundance with total density of 361,962 individual per m^3 (52% of the total composition). It was observed at highest density at station PLK3 with 151,351 individual per m^3. Among the adult forms, cyclopoid copepod recorded the highest abundance with total density of 176,977 individual per m^3 (25% of the composition) and followed by calanoid copepod with 121,722 individual per m^3 (17.49% of the composition). The highest concentration of cyclopoid was found in station PLK3 with 124,925 individual per m^3 whereas calanoid was very abundant in PLK3 with 98,498. Ecologically the planktonic copepods provide functionally important links in the aquatic food chain feeding on the microscopic algal cells of the phytoplankton and, in turn, being eaten by juvenile fish and other planktivores like sardines. Other zooplankton taxa that recorded relatively higher density were bivalve veligers (2.41%) and Balanus nauplii (1.38%). There were no fish larvae and decapod zoae recorded in all the stations sampled during this survey.

Diversity Index (H) at the sampling locations showed values as low as 0.87 (sites PLK 2) to as high as 1.25 (site PLK 3). The Evenness of index was not so variable with values ranging from 0.54 to 0.60. These indices indicate uneven zooplankton community in the area which could to the seasonality of zooplankton and timing of survey with the prevailing environmental condition. It is therefore important to interpret the result this plankton analysis in conjunction with the physio-chemical parameters, as changes in the physical environment would eventually affect the ecology of the surrounding coastal waters.

A summary of zooplankton groups recorded in three sampling stations is tabulated in **Table 2.2.26**. Photomicrograph of dominant and common plankton is shown in **Plate 2.2.13**. The highlights of the plankton community sampling are displayed in **Figure 2.2.31**.

Table 2.2.26: Zooplankton Composition, Abundance (ind/m^3), Diversity and Distribution in Three Sampling Stations; March 2021

Taxa	Stations			Grand Total	Rel. Abund.
	PLK1	PLK2	PLK3		
Adult forms	**64,865**	**14,414**	**225,025**	**304,304**	**43.73**
Calanoid copepod	21,622	1,602	98,498	121,722	17.49
Cyclopoid	41,642	10,410	124,925	176,977	25.43
Harpacticoid	1,602	0	1,602	3,203	0.46
Larvacean	0	2,402		2,402	0.35
Larval forms	**150,551**	**77,678**	**163,363**	**391,592**	**56.27**
Balanus nauplius	6,406	0	3,203	9,610	1.38
Bivalve veliger	1,602	9,610	5,606	16,817	2.42
Copepod Nauplius and Copepodites	142,543	68,068	151,351	361,962	52.01
Gastropod veliger	0	0	2,402	2,402	0.35
Polychaete Trocophore			801	801	0.12
Grand Total	**215,415**	**92,092**	**388,388**	**695,896**	**100**
Richness	**6**	**5**	**8**		
Evenness (J')	**0.56**	**0.54**	**0.60**		
Diversity (H')	**1.00**	**0.87**	**1.25**		

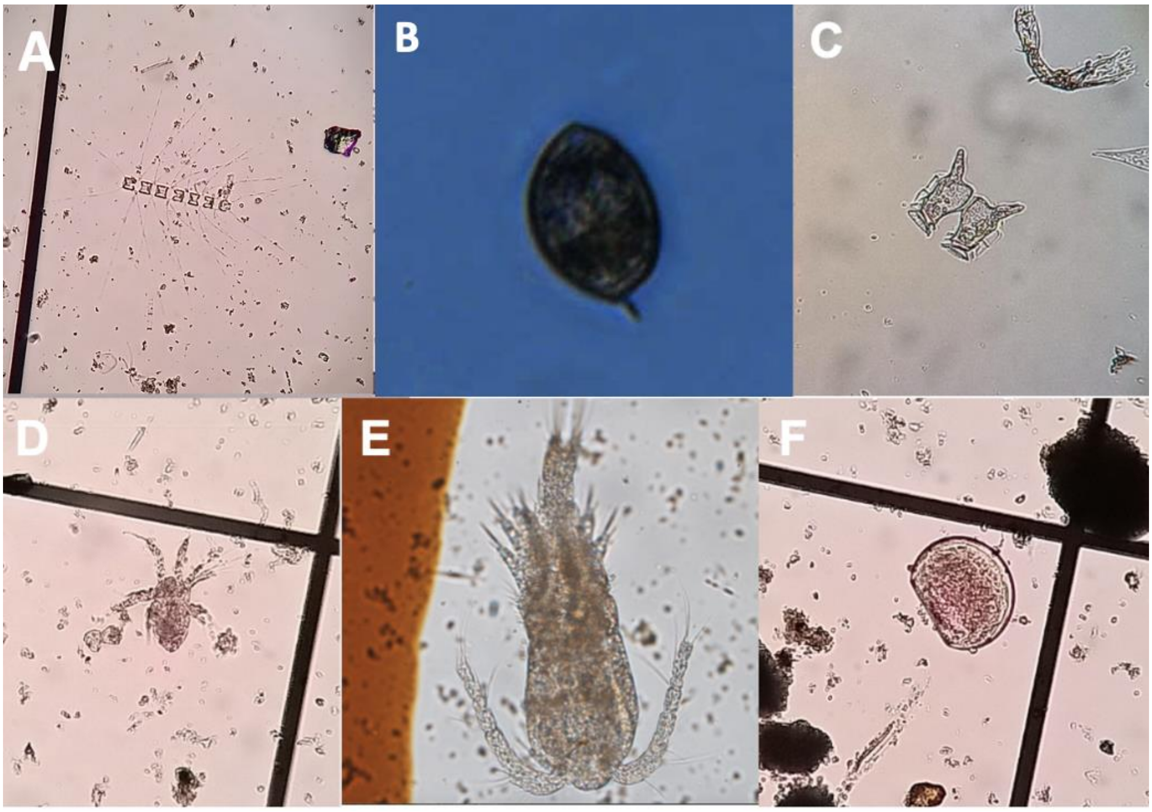


Plate 2.2.13: Dominant Plankton Species Identified in Three Sampling Stations; March 2021

Figure 2.2.31: Highlights of Results of Plankton Community Diversity Survey In Three Stations; 03 - 05 March 2021

2.2.4.4 Seagrass

A sparse seagrass meadow was observed besides an existing mine company wharf near Barangay Adlay proper. Two (2) stations were investigated employing the standard Saito-Atobe transect-quadrat method for seagrass diversity and spatial distribution, the location of which are shown in **Figure 2.2.32** and coordinates listed in **Table 2.2.27**.

Table 2.2.27: Coordinates of Stations Surveyed for Seagrass Diversity; 03-05 March 2021

Station	Latitude	Longitude	Remarks
SGR1	N 09.410890°	E 125.905430°	Recorded 1 species of *Enhalus acoroides* @ 20.5%, with the same overall subtotal percentage cover. High sedimentation may affect photosynthetic activity in this area. The rest of the substrate is sand at 79.5%
SGR2	N 09.412980°	E 125.905200°	Recorded 1 species with *Enhalus acoroides* @ 28.5%, with the same overall subtotal percentage cover. Silt intrusion blankets the seagrass and reduces water clarity in this area. The rest of the substrates is sand at 71.5%

Figure 2.2.32: Map showing the Location of Stations Surveyed for Seagrass Diversity; 03-05 March 2021

An extensive seagrass meadow is located near Barangay Adaly proper west of a mining causeway. The seagrasses are embedded in sandy-muddy substrate, in extremely turbid waters.

Since the seagrass meadow is dominated exclusively by the eel seagrass *Enhaulus acoroides*, two (2) transects were investigated for seagrass diversity in 1 m of water. The results show that the seagrass area is comprised of more than 75% silt, mud and sand, and only an average of 24.5% of the survey stations were populated by eel seagrass rhizomes (**Table 2.2.28**; **Figure 2.2.33**). Seagrass distribution was almost the same in transects 1 and 2 (20 to 28% distribution; **Figures 2.2.34** and **2.2.35**). Sediment loading is extensive and seagrass blades were vividly enveloped in silt; causing reduced photosynthesis (**Plate 2.2.14**).

In view of the absence of species diversity and impaired seagrass blades, the meadow in the surveyed area is categorized as "altered seagrass bed" under the standard criteria for evaluating seagrass beds. Summary findings from the seagrass survey is presented in a map in **Figure 2.2.36**

Table 2.2.28: Tabulated Results of Seagrass Surveys in Two Stations; March 2021

Transect No.	**Seagrass Distribution**		**Remarks/Observations**
	Species	**Percent Cover** *(in % of total)*	
1	*Enhalus acoroides*	20.50	79.50% sandy mud and sedimentation was observed in the study site which can physically smother the seagrass or cause turbidity in the water column causing impairment in photosynthesis.
	Sub-total Percentile	**21.50**	
2	*Enhalus acoroides*	28.50	71.50% sand and silt intrusion was evident and seagrass blades were blanketed with silt from river outflows, storm runoff. Water clarity in the study site is poor.
	Sub-total Percentile	**28.50**	
Average Percentile		**24.50**	**Fair Cover/Condition.**
Site Name: Purok - 6, **Barangay Adlay**			Municipality & Province: **Carrascal, Surigao del Sur**
Date: **March 4, 2020**			Observers: **Victor L. Pantaleon and Ronald T. Pocon**
Location:	Station 1: Start: 125.90543⁰ E; 09.41089⁰ N; End: 125.90535⁰ E; 09.41134⁰ N		
	Station 2: Start: 125.90520⁰ E; 09.41298⁰ N; End: 125.90529⁰ E; 09.41325⁰ N		

Note: Status Category: Poor = <5 - 20.00%; Fair = 21 - 35.00%; Good = 36.00 - 50.00%; Excellent = 51.00>

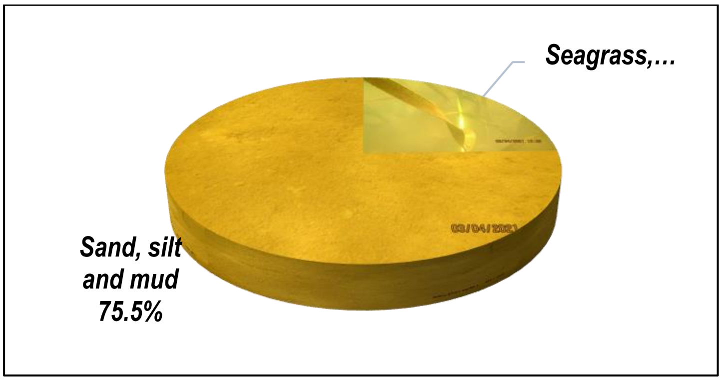


Figure 2.2.33: Summary Results of Seagrass Survey in Two Transect Stations; March 2021

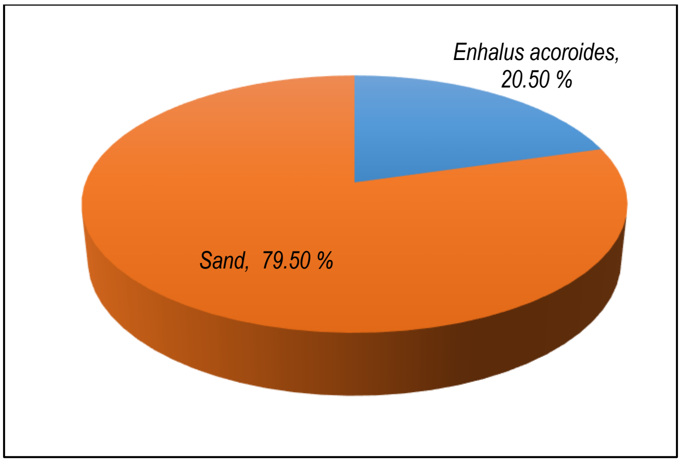


Figure 2.2.34: Relative Distribution of Seagrass Species and Bottom Substrate in Transect 1; March 4, 2021

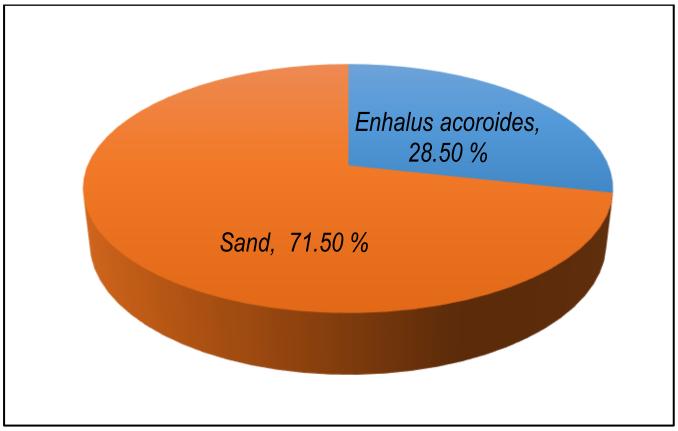


Figure 2.2.35: Relative Distribution of Seagrass Species and Bottom Substrate in Transect 2; March 4, 2021

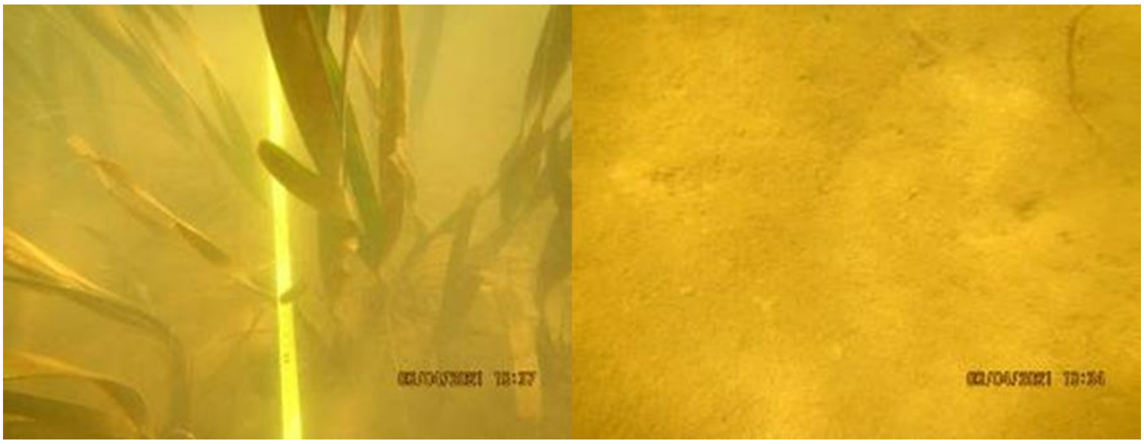


Plate 2.2.14: Silted Seagrass and Seabed Documented in Two Transect Stations; March 2021

Figure 2.2.36: Map Showing Results of Seagrass Diversity Survey; March 2021

2.2.4.5 Mangroves

Mangroves grow in intermittent stretches in the coastline of Barangay Adlay in the direct impact area of the proposed project. Three (3) stations were surveyed for species composition and distribution employing the standard transect-quadrant method. The location of the mangrove stations surveyed is shown in **Figure 2.2.37** coordinates are listed in **Table 2.2.29** (**Plate 2.2.15**).

Table 2.2.29: Coordinates of mangrove resource assessment stations; 03-05 March 2021

Station	Latitude	Longitude	Remarks
MGV1	N 09.419440°	E 125.891890°	Comprises of 104 stands distributed in 7 species. Most abundant was *Sonneratia alba* with 31 stands having a 30% composition for the recorded trees in this transect @ Nasipit River
MGV2	N 09.407600°	E 125.904300°	Comprises of 80 stands distributed in 4 species. Most abundant was *Scyphiphora hydrophyllacea* with 28 stands having a 35% composition for the recorded trees in this transect at Adlay-Marga River
MGV3	N 09.435070°	E 125.904710°	Comprises of 112 stands distributed in 3 species. Most abundant was *Lumnitzera racemosa* with 101 stands having a 90% composition for the recorded trees in this transect at Kayongan River

Plate 2.2.15: Mangrove assessment (right) being undertaken during marine ecology baseline assessment; 03-05 March 2021.

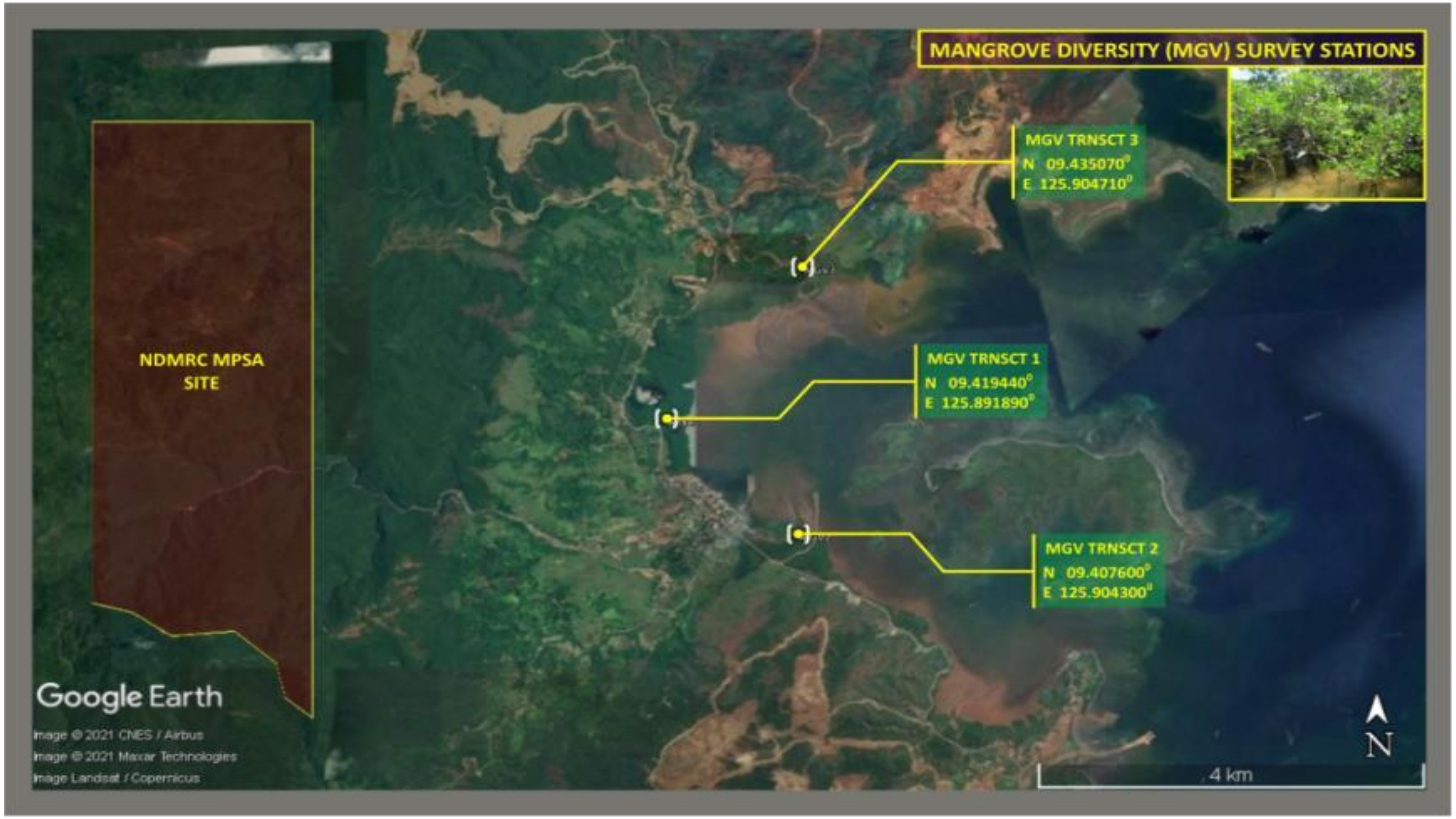


Figure 2.2.37: Map showing the Location of Stations Surveyed for Mangrove Species Diversity and Distribution; 03-05 March 2021

Mangroves were surveyed in the estuaries of three river systems – Nasipit River, Adlay River and Kay-ongan River employing the standard transect quadrant method. Identification of species distribution, average height (m) and crown diameter (m) were recorded in 10 x 10 meter quadrants, with two quadrants/station. At the same time, the number of regenerations per square meter inside the plots was also determined. The survey catalogued a total of nine (9) species across the three stations, recording a total of 296 trees, 86 seedlings and 34 saplings (**Table 2.2.30**). The diversity is considered good. The overall rating for mangrove crown cover and height, ranges from Excellent in Station 1 and 2 to Fair in Station 3 (**Table 2.2.31**) following standard categorization. *Rhizophora* spp were the highest trees, averaging 10 m for bakawang babae and 12 m for bakawang lalake. Regeneration capacity, as indicated by the number of seedlings and saplings in all stations, was rated as Excellent in all stations (**Table 2.2.31**).

Table 2.2.30: Mangrove Species Diversity and Relative Distribution in Three Survey Stations; March 2021

Site/Location	Mangrove Species	Total # of Trees/Station	Relative Abundance/Site (%)
Station 1: Nasipit River, Brgy. Adlay	*Rhizopora mucronata (Bakawan babae)* *Rhizopora apiculata (bakawan lalaki)* *Sonneratia alba (pagatpat)* *Scyphiphora hydrophyllacea (Nilad)* *Xylocarpus granatum (Tabigi)* *Avicennia marina (bungalon)* *Bruguiera gymnorrhiza (pototan)*	104	35.1
Adlay River	*Scyphiphora hydrophyllacea (Nilad)* *Sonnerratia caseolaris (Pedada)* *Rhizophora mucronata (Bakawan babae)* *Rhizopora apiculata (Bakawan lalake)*	80	27.1
Kay-ongan River	*Lumnitzera racemosa(culasi))* *Sonnerratia caseolaris (Pedada)* *Rhizophora mucronata (Bakawan babae)*	112	37.8
Total Number of Trees, 3 stations		**296**	**100%**

Mangroves in station 1 were dominated by *Sonneratia alba (Pagtpat)*, comprising 30% of the mangrove community in two quadrats followed by *Rhizopora apiculata (Bakawan lalaki)* at 19% of the community and *Rhizopora mucronata (bakawan babae)* at 13% relative distribution (**Figure 2.2.38**). Trees comprised 66% of the forest, seedlings 23%, and saplings at 11% of all trees. Crown cover was *Xylocarpus granatum (Tabigi)* averaging 6.31 m, followed by at 4.34 m (**Figure 2.2.39**). Height of trees was recorded highest with *Scyphiphora hydrophyllacea (Nilad), Sonneria alba* and *Rhizopora mucronata* (**Figure 2.2.40**). Average diameter at breast height ranged from 15. 6 to 26.7 cm, suggesting some trees are old growth.

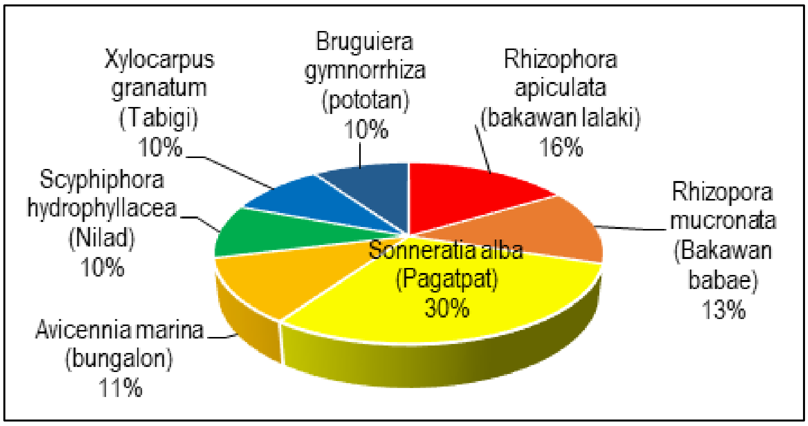


Figure 2.2.38: Relative Distribution of Mangroves by Species in Station 1; March 2021

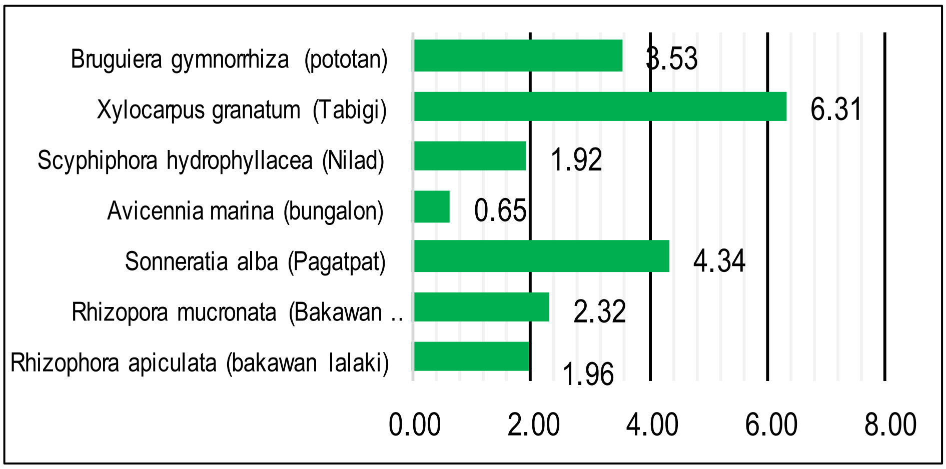


Figure 2.2.39: Average Crown Cover of Mangrove Tress in Station1; March 2021

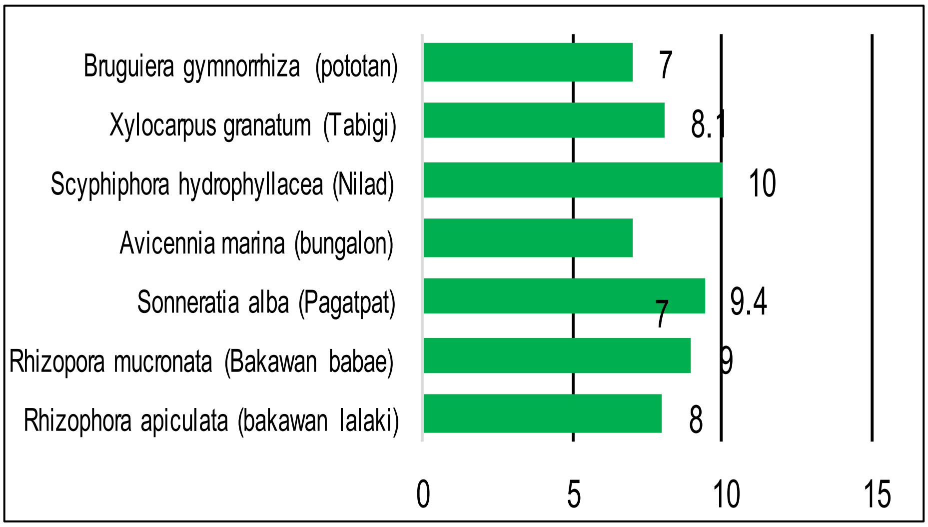


Figure 2.2.40: Average Height of Mangrove Tress in Station1; March 2021

Table 2.2.31: Mangrove Species Diversity and Growth Parameters in Mangrove Station 1; March 2021

Transect No. 1	Species	No. of trees	GBH Diameter(cm)		Height (m)		Crown Diameter (m)		Remarks
			Reading Ave.	DBH	Reading Ave.	Height	Reading Ave.	C. Cover	
Q1	*Rhizophora apiculata (bakawan lalaki)*	1	20	6.37	3	3	1	0.79	✓ Substrate: Silt/Muddy ✓ No presence of garbage/wastes ✓ Presence of birds, juvenile fishes and shells ✓ Seedlings-20 ✓ Saplings-10
	Rhizophora apiculata (bakawan lalaki)	1	15	4.77	2	2	0.5	0.20	
	Rhizophora apiculata (bakawan lalaki)	5	16	25.46	3	15	0.5	0.98	
	Rhizophora apiculata (bakawan lalaki)	2	25	15.92	4	8	1	1.57	
	Rhizophora apiculata (bakawan lalaki)	2	29	18.46	4	8	1.5	3.53	
	Rhizophora mucronata (Bakawan babae)	1	17	5.41	2	2	1	0.79	
	Rhizophora mucronata (Bakawan babae)	3	15	14.32	3	9	1	2.36	
	Rhizophora mucronata (Bakawan babae)	3	30	28.65	4	12	1.5	5.30	
	Sonneratia alba (Pagatpat)	3	17	16.23	5	15	0.5	0.59	
	Sonneratia alba (Pagatpat)	2	38	24.19	8	16	1.5	3.53	
	Sonneratia alba (Pagatpat)	1	24	7.64	6	6	1	0.79	
	Sonneratia alba (Pagatpat)	1	27	8.59	6	6	1	0.79	
	Sonneratia alba (Pagatpat)	1	12	3.82	2	2	1	0.79	
	Sonneratia alba (Pagatpat)	1	36	11.46	8	8	2	3.14	
	Sonneratia alba (Pagatpat)	1	21	6.68	7	7	1	0.79	
	Sonneratia alba (Pagatpat)	2	14	8.91	4	8	0.5	0.39	
	Sonneratia alba (Pagatpat)	1	16	5.09	4	4	1	0.79	
	Scyphiphora hydrophyllacea (Nilad)	7	8	17.83	1	7	0.5	1.37	
	Scyphiphora hydrophyllacea (Nilad)	2	23	14.64	4	8	0.5	0.39	
	Scyphiphora hydrophyllacea (Nilad)	1	27	8.59	5	5	0.5	0.20	
	Xylocarpus granatum (Tabigi)	5	24	38.20	5	25	1	3.93	
	Xylocarpus granatum (Tabigi)	2	30	19.10	6	12	1	1.57	
	Xylocarpus granatum (Tabigi)	1	34	10.82	6	6	2	3.14	
	Xylocarpus granatum (Tabigi)	1	65	20.69	5	5	1	0.79	
	Xylocarpus granatum (Tabigi)	1	25	7.96	2	2	0.5	0.20	
	Avicennia marina(bungalon)	1	130	41.38	8	8	4	12.57	
	Avicennia marina(bungalon)	1	23	7.32	3	3	1	0.79	
	Avicennia marina(bungalon)	1	75	23.87	7	7	3	7.07	
	Avicennia marina(bungalon)	1	41	13.05	7	7	2	3.14	
	Avicennia marina(bungalon)	1	29	9.23	4	4	1.5	1.77	
	Rhizophora mucronata (Bakawan babae)	4	14	17.83	4	16	0.5	0.79	
	Rhizophora mucronata (Bakawan babae)	3	19	18.14	2	6	1	2.36	
	Rhizophora apiculata (Bakawan lalake)	6	12	22.92	2	12	1	4.71	
	Sonneratia alba (Pagatpat)	2	56	35.65	8	16	3	14.14	

Transect No. 1	Species	No. of trees	GBH Diameter(cm) Reading Ave.	GBH Diameter(cm) DBH	Height (m) Reading Ave.	Height (m) Height	Crown Diameter (m) Reading Ave.	Crown Diameter (m) C. Cover	Remarks
Q2	*Sonneratia alba (Pagatpat)*	1	43	13.69	8	8	3.5	9.62	✓ Substrate: Silt/Muddy ✓ No garbage/wastes ✓ Presence of birds with very few gastropods ✓ Seedlings-16 ✓ Saplings-7
	Sonneratia alba (Pagatpat)	1	16	5.09	3	3	0.5	0.20	
	Sonneratia alba (Pagatpat)	1	28	8.91	8	8	4	12.57	
	Sonneratia alba (Pagatpat)	1	27	8.59	6	6	1	0.79	
	Sonneratia alba (Pagatpat)	4	21	26.74	4	16	0.5	0.79	
	Sonneratia alba (Pagatpat)	2	49	31.19	6	12	2	6.28	
	Sonneratia alba (Pagatpat)	1	44	14.01	8	8	3	7.07	
	Sonneratia alba (Pagatpat)	3	29	27.69	5	15	1.5	5.30	
	Sonneratia alba (Pagatpat)	2	135	85.94	7	14	3	14.14	
	Avicennia marina (bungalon)	2	135	85.94	8	16	4	25.13	
	Avicennia marina (bungalon)	3	39	37.24	6	18	1	2.36	
	Avicennia marina (bungalon)	1	42	13.37	5	5	1	0.79	
	Avicennia marina (bungalon)	1	29	9.23	5	5	2	3.14	
	Bruguiera gymnorrhiza (pototan)	3	30	28.65	5	15	2	9.42	
	Bruguiera gymnorrhiza (pototan)	3	32	30.56	4	12	1.5	5.30	
	Bruguiera gymnorrhiza (pototan)	1	20	6.37	3	3	1	0.79	
	Bruguiera gymnorrhiza (pototan)	1	24	7.64	4	4	1.5	1.77	
	Bruguiera gymnorrhiza (pototan)	1	44	14.01	3	3	1	0.79	
	Bruguiera gymnorrhiza (pototan)	1	48	15.28	5	5	2	3.14	
Grand Total		**104**		**1009.36**		**456**		**195.37**	**Seedlings-36 Saplings-17**

SUMMARY RESULTS			
Condition	**Criteria**	TOTAL CROWN COVER:	195.37
Excellent	**76% and above in % crown cover 1 regeneration per m² Above 5m in average tree height Undisturbed to negligible disturbance**	PERCENT CROWN COVER: TOTAL HEIGHT OF ALL TREES:	195.37 /(2 quadratsx100sq.m) = 97.69% **(excellent condition)** 456
Good	**51-75% crown cover <1-0.76% regeneration per m² <5m-3m average height of trees Slight disturbance and few cuttings**	AVERAGE HEIGHT: TOTAL DBH AVERARAGE DBH OF ALL TREES	**456/104 trees= 4.39meter (good condition)** **1009.36** **1009.36/104 trees= 9.43cm**
Fair	**26-50% crown cover 0.50-0.76 regeneration per m² <3m-2m average height of trees Moderate disturbance and noticeable cuttings**	Total regeneration count Regeneration per square meter = --- Total number of regeneration plot 36 seedlings/6 plots (3 plots per quadrat) = **6% regeneration per m² (excellent condition)**	

Four (4) species comprised the mangrove community in Station 2 in the Adlay River with *Scyphiphora hydrophyllacea* accounting for 35% of the community (26 trees), followed by *Rhizopora apiculata* at 28% and *Sonneratia caseoralis* at 22% (**Table 2.2.32**; **Figure 2.2.41**). Crown cover was biggest with the Pedada trees (12.48m) followed by *Rhizophora apiculata* at 5.5 m (**Figure 2.2.42**). The Nilad trees in this station were relatively small. *Rhizophora apiculata* dominated height of mangroves, averaging 22 m (**Figure 2.2.43**) even as this species comprised only 28% of the community. Regeneration capacity was rated as Excellent, with 33 seedlings and 12 saplings. Average diameter at breast height ranged from 18.45 cm to 36.6 cm, in fact indicating many of the mangroves are old growth trees.

Table 2.2.32: Mangrove Species Diversity and Growth Parameters in Station 2; March 2021

Transect No. 1	Species	No. of trees	GBH Diameter (cm)		Height (m)		Crown Diameter (m)		Remarks
			Reading Ave.	DBH	Reading Ave.	Height	Reading Ave.	C. Cover	
Q1	*Scyphiphora hydrophyllacea (Nilad)*	5	8	12.73	1	5	0.5	0.98	✓ Substrate: Silt/muddy ✓ No arbage/wastes ✓ Presence of birds, juvenile fishes and few gastropods ✓ Seedlings-17 ✓ Saplings-5
		1	12	3.82	2	2	0.5	0.20	
		5	16	25.46	3	15	0.5	0.98	
		5	11	17.51	4	20	1	3.93	
		3	20	19.10	3	9	0.5	0.59	
	Sonnerratia caseolaris (Pedada)	1	35	11.14	6	6	3	7.07	
		1	4	1.27	6	6	2	3.14	
		1	42	13.37	8	8	4	12.57	
		3	22	21.01	6	18	3	21.21	
		2	56	35.65	10	20	4	25.13	
		3	26	24.83	3	9	1	2.36	
		2	118	75.12	12	24	4	25.13	
	Rhizophora mucronata (Bakawan babae)	2	26	16.55	3	6	1	1.57	
		1	17	5.41	3	3	1	0.79	
		9	26	74.48	4	36	1	7.07	
	Rhizophora apiculata (Bakawan lalake)	6	18	34.38	3	18	1	4.71	
		7	14	31.19	3	21	1	5.50	
Q2	*Scyphiphora hydrophyllacea (Nilad)*	5	27	42.97	3	15	0.5	0.98	✓ Substrate: Silt/muddy ✓ No presence of garbage/wastes ✓ Presence of birds and shells ✓ Seedlings-16 ✓ Saplings-7
		1	10	3.18	2	2	0.5	0.20	
		3	24	22.92	4	12	1	2.36	
	Sonnerratia caseolaris (Pedada)	2	63	40.11	8	16	2	6.28	
		3	39	37.24	6	18	2	9.42	
	Rhizophora apiculata (Bakawan lalake)	4	20	25.46	5	20	1	3.14	
		5	35	55.70	6	30	1.5	8.84	
Grand Total		**80**		**650.62**		**339**		**154.13**	**Seedlings-33** **Saplings-12**

SUMMARY RESULTS

Condition	**Criteria**	TOTAL CROWN COVER:	154.13
Excellent	**76% and above in % crown cover** **1 regeneration per m²** **Above 5m in average tree height** **Undisturbed to negligible disturbance**	PERCENT CROWN COVER: TOTAL HEIGHT OF ALL TREES:	154.13/(2 quadratsx100sq.m) = 77.07**% (excellent condition)** 339
Good	**51-75% crown cover** **<1-0.76% regeneration per m²** **<5m-3m average height of trees** **Slight disturbance and few cuttings**	AVERAGE HEIGHT: TOTAL DBH AVERARAGE DBH OF ALL TREES	**339/80 trees= 4.24 m (good condition)** **650.52** **650.52/80 trees=8.13cm**
Fair	**26-50% crown cover** **0.50-0.76 regeneration per m²** **<3m-2m average height of trees** **Moderate disturbance and noticeable cuttings**	Total regeneration count Regeneration per square meter = ---	
Poor	**25% crown cover** **0.50 regeneration per ²** **<2m average height of trees** **Heavy disturbance/cuttings/pollution, rampant conversion to other uses, nearly destroyed**	Total number of regeneration plot 33 seedlings/6 plots (3 plots per quadrat) = **5.5% regeneration per m² (excellent condition)**	

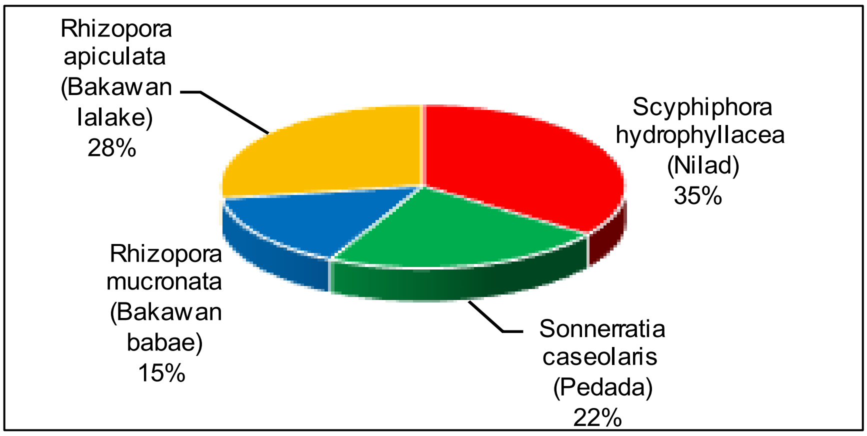


Figure 2.2.41: Relative Distribution of Mangroves by Species in Station 2; March 2021

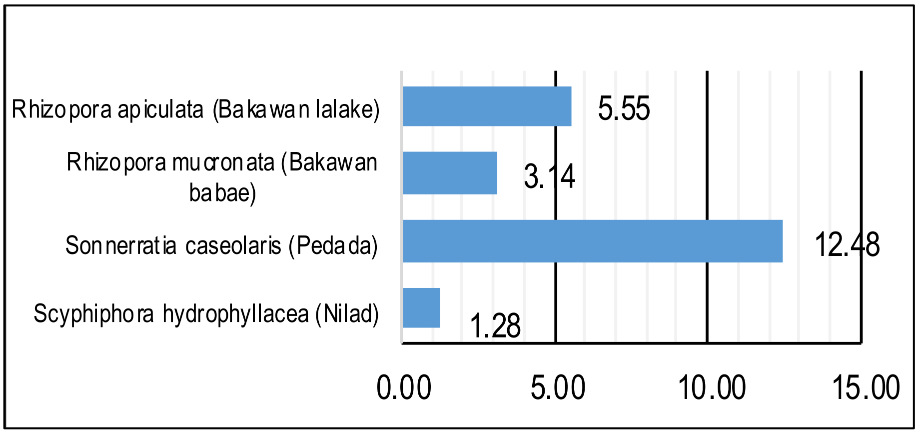


Figure 2.2.42: Average Crown Cover of Mangrove Tress in Station 2; March 2021

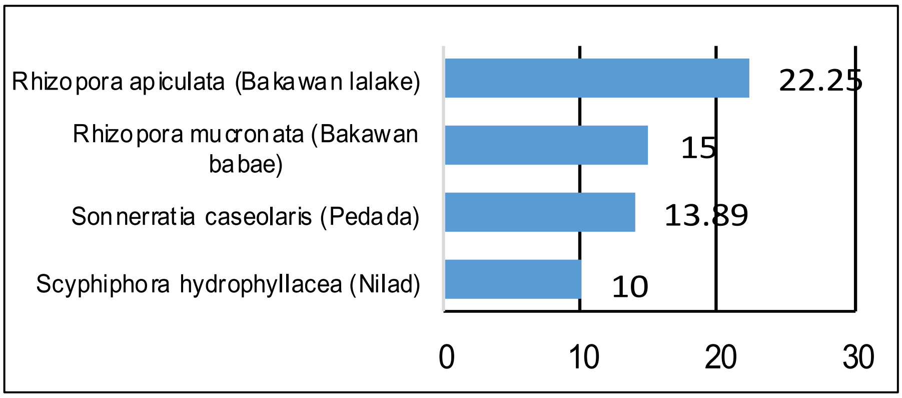


Figure 2.2.43: Average Height of Mangrove Tress in Station 2; March 2021

A tight community of 112 trees was catalogued in Station 3 in the Kay-ongan River estuary, with only three species. The mangroves sampled here represent 37.8% of the total mangrove trees counted in three sampling stations (**Table 2.2.33**). The mangrove community was comprised of three (3) species dominated by *Lumnitzera racemosa* (Culasit) at 90% of relative abundance; (**Figure 2.2.44**). *Rhizopora mucronata* and *Lumnitzera racemosa* also dominated crown cover in this particular site, averaging 5.1 and 5.6 m, respectively (**Figure 2.2.45**). The same species dominated average height at 36.2 m (**Figure 2.2.46**). There were 17 seedlings and 5 saplings in station 3, suggesting excellent regeneration capacity.

Table 2.2.33: Mangrove Species Diversity and growth Parameters Catalogued in Station 3 (Kay-ongan River); March 2021

Transect No. 1	Species	No. of trees	GBH Diameter (cm)		Height (m)		Crown Diameter (m)		Remarks
			Reading Ave.	DBH	Reading Ave.	Height	Reading Ave.	C. Cover	
Q1	*Lumnitzera racemosa(culasi)*	6	20	38.20	4	24	0.5	1.18	✓ Substrate: Silt/muddy ✓ No presence of garbage/wastes ✓ Presence of birds, juvenile fishes and shells ✓ Seedlings-8 ✓ Saplings-5
		18	10	57.30	3	54	0.5	3.53	
		16	7	35.65	3	48	1	12.57	
		8	30	76.39	5	40	1	6.28	
		5	57	90.72	7	35	1.5	8.84	
	Rhizophora mucronata (Bakawan babae)	3	7	6.68	2	6	0.5	0.59	
		6	12	22.92	4	24	1.5	10.60	
Q2	*Lumnitzera racemosa(culasi)*	3	77	73.53	6	18	1.5	5.30	✓ Substrate: Silt/muddy ✓ No presence of garbage/wastes ✓ Presence of birds and shells ✓ Seedlings-9 ✓ Saplings-0
		7	46	102.50	3	21	1	5.50	
		6	26	49.66	3	18	0.5	1.18	
		7	14	31.19	5	35	0.5	1.37	
		15	9	42.97	3	45	0.5	2.95	
		10	38	120.96	6	60	1	7.85	
	Sonnerratia caseolaris (Pedada)	1	30	9.55	8	8	2	3.14	
		1	16	5.09	6	6	1.5	1.77	
Grand Total		**112**		**763.31**		**442**		**72.65**	**Seedlings-17** **Saplings-5**

SUMMARY RESULTS

Condition	Criteria		
		TOTAL CROWN COVER:	72.65
Excellent	**76% and above in % crown cover** **1 regeneration per m²** **Above 5m in average tree height** **Undisturbed to negligible disturbance**	PERCENT CROWN COVER:	72.65 /(2 quadratsx100sq.m) = 36.33% **(fair condition)**
		TOTAL HEIGHT OF ALL TREES:	442
Good	**51-75% crown cover** **<1-0.76% regeneration per m²** **<5m-3m average height of trees** **Slight disturbance and few cuttings**	AVERAGE HEIGHT:	**442/112 trees= 3.95 meter (good condition)**
		TOTAL DBH	**763.31**
		AVERARAGE DBH OF ALL TREES	**763.31/112trees= 6.82cm**
Fair	**26-50% crown cover** **0.50-0.76 regeneration per m²** **<3m-2m average height of trees** **Moderate disturbance and noticeable cuttings**	Total regeneration count Regeneration per square meter = --- Total number of regeneration plot	
Poor	**25% crown cover** **0.50 regeneration per ²** **<2m average height of trees** **Heavy disturbance/cuttings/pollution, rampant conversion to other uses, nearly destroyed**	17 seedlings/6 plots (3 plots per quadrat) = **2.83% regeneration per m² (excellent condition)**	

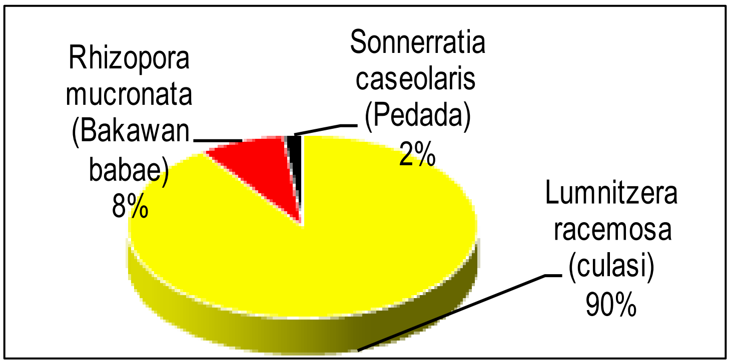


Figure 2.2.44: Relative Distribution of Mangroves by Species in Station 3; March 2021

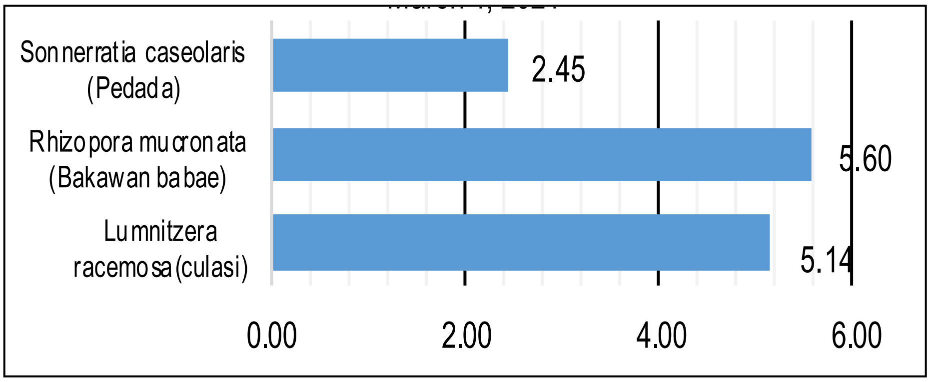


Figure 2.2.45: Average Crown Cover of Mangrove Tress in Station 3; March 2021

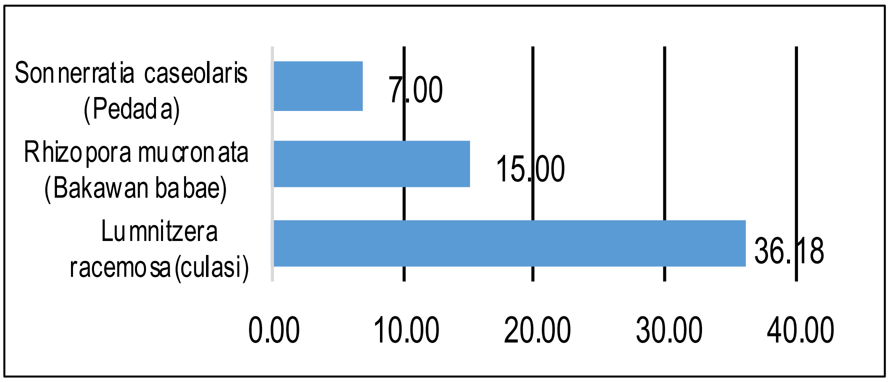


Figure 2.2.46: Average Height of Mangrove Tress in Station 3; March 2021

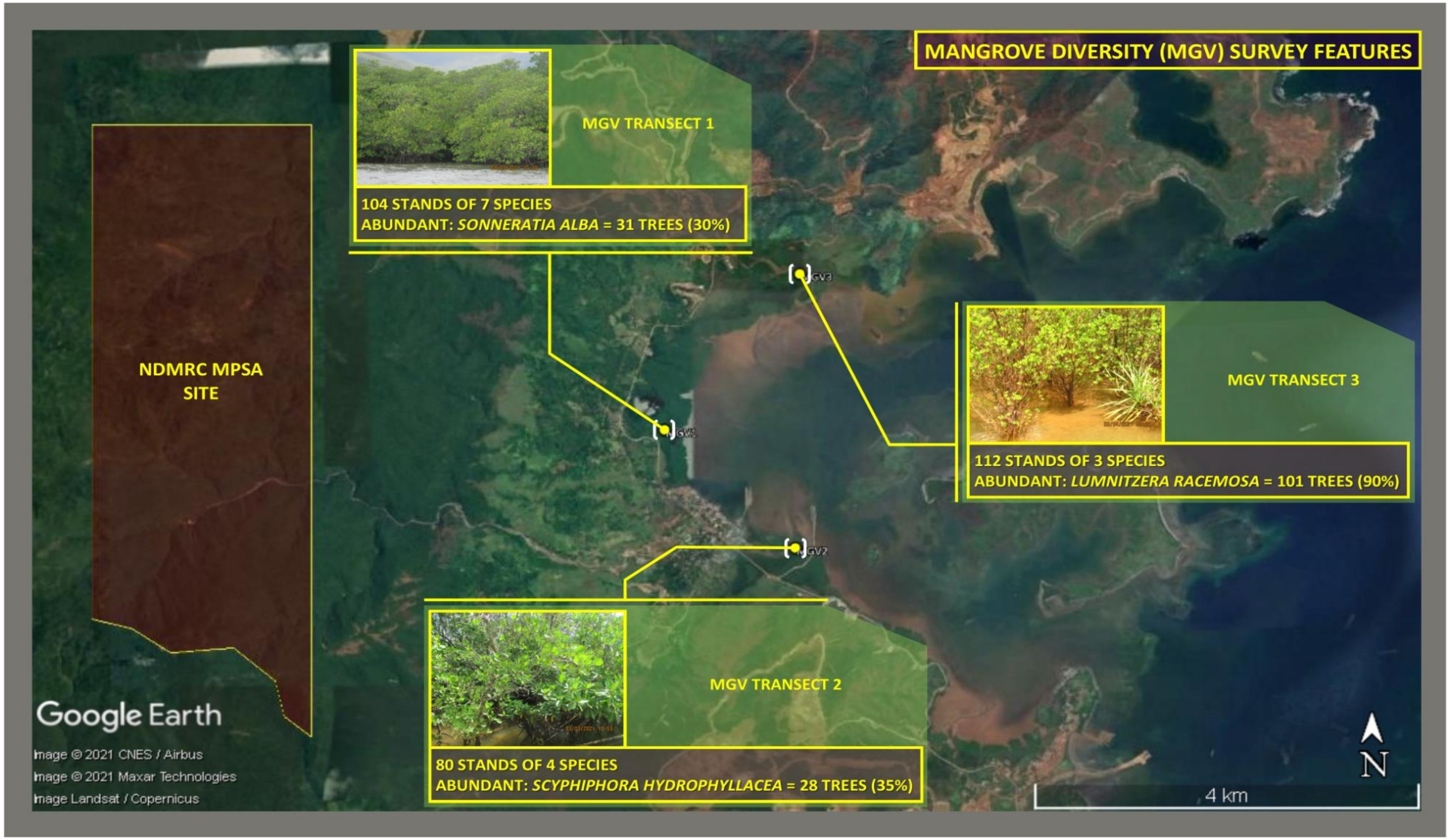


Figure 2.2.47: Mangrove Species Diversity and Relative Distribution in Three Survey Stations; March 2021

2.2.4.6 Nearshore Fisheries

The rapid fisheries appraisal was undertaken through key informant interviews to determine (i) presence of fishing activities in the study area and dominant fishing gears used, (ii) usual catch composition, (iii) estimated catch rates, and (iv) issues affecting fisheries. In the coastal waters fronting Barangay Adlay, five groups of fishers conducting actual fishing operations were interviewed and catch composition and catch rate was documented for real time catch and effort data. The coordinates of five (5) actual fishing encounters are shown in **Table 2.2.34** and **Figure 2.2.48**; **Plate 2.2.16**.

Table 2.2.34: Coordinates of Actual Fishing Stations; March 2021

Station	Latitude	Longitude	Remarks
AFE1	N 09.410180°	E 125.912480°	One fisher from Barangay Adlay, Carrascal, Surigao Del Sur using hook and line encountered with a catch of various fish species such as emperor, grouper, sweetlips, and endeavor shrimp approximated at 0.5 kg caught by means of hook and line (*Bingwit/Pasol*) in 3 hours fishing time; CPUE = 0.16 kg/fishing hour
AFE2	N 09.426430°	E 125.914900°	One fisher from Barangay Adlay, Carrascal, Surigao Del Sur employing hook and line encountered with a catch of various fish species such as snapper, spinecheek, wrasse, and grouper approximated at 0.5 kg caught by means of hook and line (*Bingwit/Pasol*) in 3 hours fishing time; CPUE = 0.16 kg/fishing hour
AFE3	N 09.422400°	E 125.915630°	One fisher from Barangay Adlay, Carrascal, Surigao Del Sur using hook and line documented with a catch of various fish species such as honeycomb grouper, damselfish, triggerfish, snappers, and wrasse approximated at 1.3 kg caught by means of hook and line (*Bingwit/Pasol*) in 4 hours fishing time; CPUE = 0.32 kg/fishing hour
AFE4	N 09.418600°	E 125.910560°	One fisher from Barangay Adlay, Carrascal, Surigao Del Sur using hook and line documented with a catch of various fish species such as snapper, spinecheek, damselfish, triggerfish, and wrasse approximated at 1.0 kg caught by means of hook and line (*Bingwit/Pasol*) in 4 hours fishing time; CPUE = 0.25 kg/fishing hour
AFE5	N 09.409100°	E 125.907390°	Three fishers from Purok 6 Barangay Adlay, Carrascal, Surigao Del Sur using surface gill net with scaring device (*timbog)* documented with a catch of various fish species such as indian mackerel, common whiting, jobfish, ponyfish, mullet, and rabbitfish approximated at 2.5 kg caught by means of surface gill net with scaring device (*Pukot palugdang*) in 6 hours fishing time; CPUE = 0.41 kg/fishing hour

Plate 2.2.16: In-situ Documentation of Catch per Unit Effort (CPUE) of Actual Fishing Operation; 03-05 March 2021

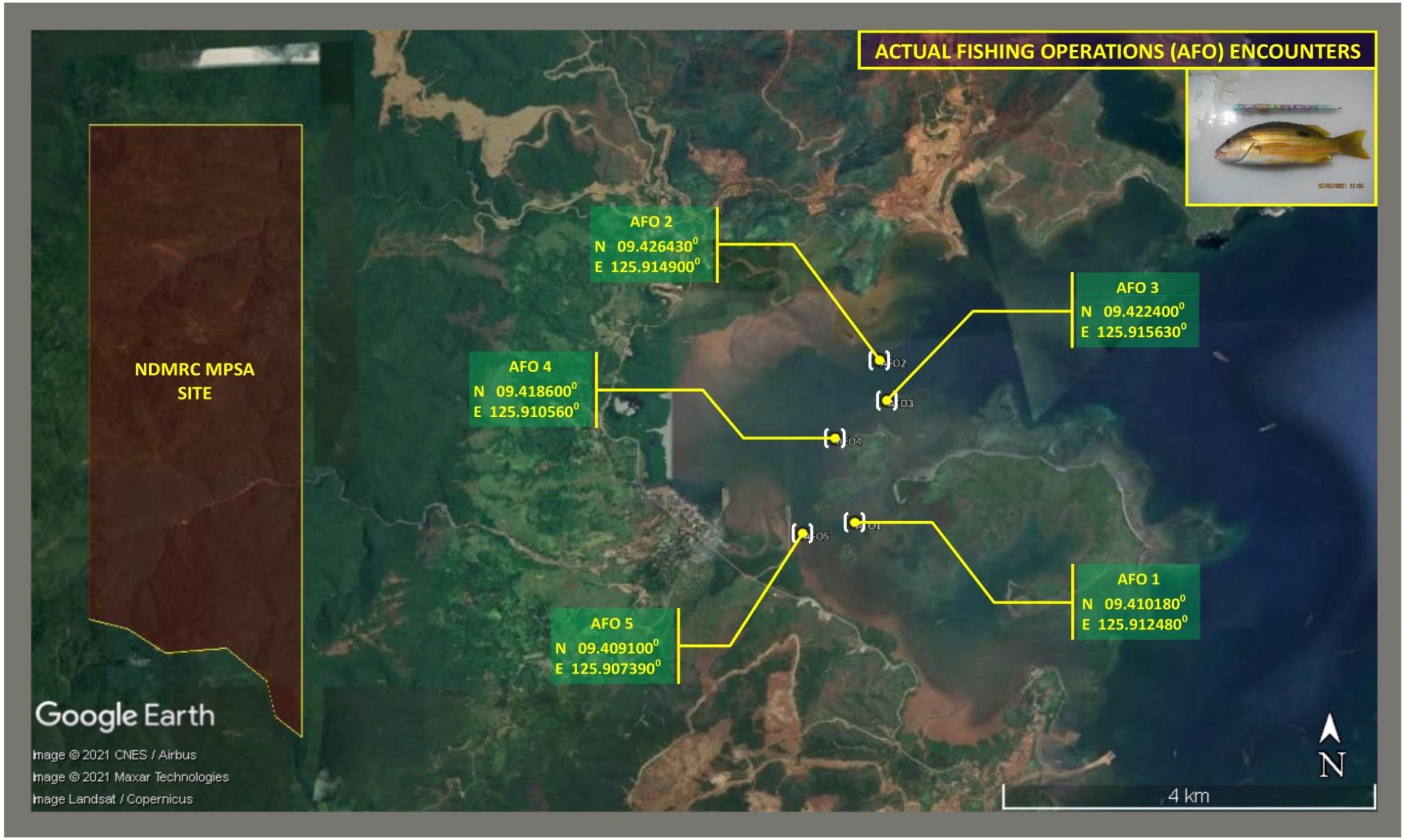


Figure 2.2.48: Map showing the Location of Stations Surveyed for Fisheries Catch Composition and Catch Per Unit Effort; 03-05 March 2021

In-situ documentation of five actual fishing operations by sustenance fishers in Carrascal Bay was documented during the survey for actual catch composition and catch rate. Four of the five fishing boats observed were non-motorized. All of the fishers documented had catch per unit effort (CPUE) ranging from 0.5 to 1.3 kg of fish per hour. The highest was obtained by a hook and line operator nearthe vicinity of the Adlay MPA with1.3kg CPUE in four hours fishing time. The catch per unit effort is low in all the fishing operations encountered. Except for the Indian mackerel caught by gill net with "timbog", all the fishes caught were of juvenile size (**Plate 2.2.17** and **Figure 2.2.49**). Moreover, the fishers claimed progressive decline in catch rate and size of fish at capture. They cited increasing turbidity in the bay as a major cause for the decline in fish stocks but growth and recruitment overfishing is most likely a more plausible cause.

Note: Top row: Yellowmargin triggerfish (Pseudobalistes flavimarginatus) "Pugot/Pakol"; Sixbar grouper (Epinephelus sexfaciatus) "Lapu-lapu / Dulit"; 2nd row: Saw-jawed monocle bream (Scolopsis ciliata) "Lagaw"; Pink ear emperor (Lethrinus lentjan) "Katambak"; Two-spot banded snapper (Lutjanus biguttatus) "Labongan / Kendi-kendi"; Large spot sweetlip (Plectorhincus macrospilus) "Lepti"; 3rd row: Yellow-lip emperor (Lethrinus xanthochilus) "Katambak", Humpback red snapper (Lutjanus gibbus) "Maya-maya", Redbreasted wrasse (Chellinus fasciatus) "Maming / Ipos-ipos", Ornate emperor (Lethrinus ornatus) "Katambak", Last row: Checkered snapper (Lutjanus decussatus) "Dulisan", Brown-barred grouper (Cephalopdis boenak), Triple-tailed wrasse (Cheilinus trilobatus) "Labayan / Lubay-lubayan / Labajan" (photographs by Victor L. Pantaleon, Ronald T. Pocon and Ernie P. Fontamillas).

Plate 2.2.17: Common Species of Fish Caught by Small-Scale Fishers in Carrascal Bay

A total of forty-one (41) species of fish were documented in the documentation of catch and effort. Labrids (wrasses) and Lutjanids (snapper) were more numerous than other species caught. One species – the humphead wrasse (*Cheilinus undulatus*) is listed in the IUCN Red List as Endangered while the triplespot damselfish *Dascyllus trimaculatus* is listed as Vulnerable (**Table 2.2.35**). Philippine fishery laws prohibit the capture of the humphead wrasse (Mameng). Highlights of actual observation of catch per unit effort are presented n **Figure 2.2.49**.

Table 2.2.35: Catch Composition by Family and Species (with IUCN Red List Classification) of Small-Scale Fisheries in Carrascal Bay; 03 - 05 March 2021

Family	Species Name	Local Name	Common Name	IUCN Red List Status
1. Nemipteridae	*Nemipterus spp.*	Bisugo	Threadfin bream	Least Concern
2. Balistidae	*Pseudobalistes flavimarginatus*	Pakol	Triggerfish	Unknown/Not assessed
3. Balistidae	*Balistoides viridescens*	Pakol	Titan tiggerfish	Unknown/Not assessed
4. Seranidae	*Epinephelus sexfaciatus)*	Lapu-lapo	Six-bar Grouper	Not assessed
5. Seranidae	*Cephalopdis boenak*	Lapu-lapo	Brown-barred grouper	Unknown/Not assessed
6. Seranidae	*Ephinepalus merra*	Lapu-lapo	Honeycomb grouper	Unknown/Not assessed
7. Letrinidae	*Letrinus sp*	Katambak	Jobfish/emperor	Not assessed
8. Acanthuridae	*Acanthurus bleekeri*	Labahita	Surgeonfish	Least Concern
9. Carangidae	*Alepes vari*	Salay	Herring scad	Least concern
10. Carangidae	*Selar boops*	Matang baka	Ox-eye scad	Least concern
11. Theraponidae	*Therapon jarbua*	Bugaong	Convex-lined therapon	Unknown/Not assessed
12. Large spot sweetlip	*Plectorhincus macrospilus*	Lipti	Large spot sweetlip	Unknown/Not assessed
13. Mugilidae	*Chelon macrolepis*	Banak/Gusaw	largescale mullet	Not assessed
14. Mugilidae	*Valamugil sehei*	Banak/Aligasin	Blue-spot mullet	Not assessed
15. Penaeidae	*Nematopalaemon tenuepsis*	Pasayan/hipon	Endeavor shrimp	Unknown/Not assessed
16. Carangidae	*Atule mate*	Salay	Yellowtail scad	Unknown/Not assessed
17. Lutjanidae	*Lutjanus argentimaculatus*	Mangrove snapper	Mangagat	Least Concern
18. Lutjanidae	*Lutjanus monostigma*	One-spot snapper	Maya-maya	Least concern
19. Lutjanidae	*Lutjanus decussatus*	Checkered snapper	Saging-saging	Least Concern but Decreasing
20. Lutjanidae	*Lutjanus bigutatus*	Two-spot banded snapper	Maya-maya	Not assessed
21. Nemipteridae	*Scolopsis sp*	Monocle bream	SIlay	Least concern
22. Nemipteridae	*Pentapodus trivittatus*	Three-striped whiptail	SIlay	Stable – Least Concern
23. Letrinidae	*Letrinus ornatus*	Ornate emperor	Katambak	Unknown/Not assessed
24. Letrinidae	*Lethrinus xanthochilus*	Yellow-lip emperor	Katambak	Least concern
25. Nemipteridae	*Letrinus lentjan*	Pink-ear emperor	Katambak	Not assessed
26. Nemipteridae	*Scolopsis ciliata*	Saw-jawed monocle bream	Lagaw	Least concern
27. Nemipteridae	*Oxycheilinus diagrammus*	Small-toothed whiptail	Lagaw	Not assessed
28. Lutjanide	*Pristipomoides sieboldii*	Lavander jobfish	Sagisi	Least Concern
29. Scombridae	*Rastrelliger kanagurta*	Alumahan	Indian mackerel	Data Defficient
30. Sillaginidae	*Sillago sihama*	Asohos	Common whiting	Least Concern
31. Siganidae	*Siganus javus*	Samaral	Java rabbitfish	Least Concern
32. Pomacentridae	*Dascyllus trimaculatus*	Threespot damselfish	Palata	**Vulnerable**
33. Pomacentridae	*Hemiglyphidodon plagiametapon*	Damselfish	Palata	Unknown
34. Labridae	*Cheilio inemis*	Cigar wrasse	mulmol	Unknown
35. Labridae	*Oxycheilinus diagrammus*	Violet-lined maori wrasse	Labayan	Least Concern
36. Labridae	*Cheilinus undulatus*	Humphead wrasse	Maming	**Endangered**
37. Labridae	*Thalasoma hardwicke*	Sixbar wrasse	Labayan	Unknown
38. Labridae	*Cheilinus trilobatus*	Triple tail wrasse	Labayan	Least Concern
39. Leiognathidae	*Gaza minuta*	Toothed ponyfish	Sap-sap	Not assessed
40. Carangidae	*Selaroides leptolepis*	Yellow-striped trevally	Salay ginto	Least Concern
41. Scaridae	*Scarus spp*	Parrotfish	Mul-mol	Unknown

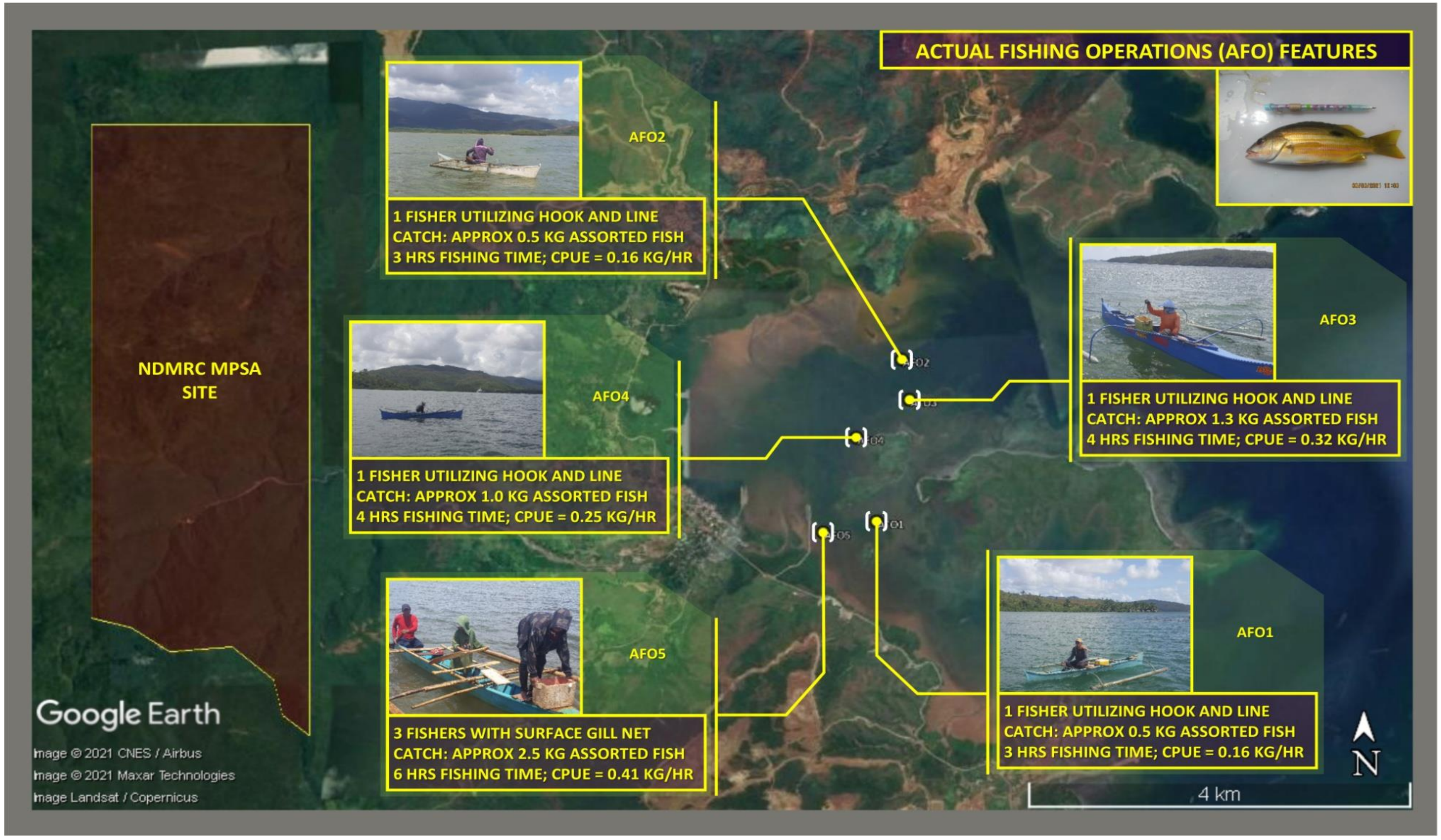


Figure 2.2.49: Results of Actual Fishing Documentation in Carrascal Bay; 03 - 05 March 2021

2.2.4.7 Macro-invertebrates

A supplementary survey of macro-invertebrates focusing on species that are gathered for food or for selling by local fishers was conducted on 03-04 March 2021 in the estuaries of two river systems and in a station near Alingating shoal that key informants claimed is a gleaning area for shellfish. The macro-invertebrate station coordinates are detailed in **Table 2.2.36** and locations are displayed in **Figure 2.2.50**).

Table 2.2.36: Coordinates of Stations Surveyed for Presence of Macro-Invertebrates; 03-05 March 2021

Station	Latitude	Longitude	Remarks
MAC1	N 09.423920°	E 125.920940°	One (1) male gleaner coming from Purok - 6 Barangay Adlay, Carrascal, Surigao del Sur, gleaning outside the Adlay MPA (with an initial harvest of 50 pieces macro-invertebrate species purely composed of 50 pieces spider conch (*Lambis lambis*)
MAC2	N 09.435210°	E 125.904920°	Rayed pearl oyster (*Pinctada imbricata*), "Dayo-dayo", and Algae sea snail (*Nerita polita*) at Kayongan River, Barangay Adlay, Carrascal, Surigao del Sur
MAC3	N 09.419410°	E 125.893080°	Crass turban sea snail (*Turbo crassus*), Punctate codakia (*Codakia punctata*) "Litob" and Brown fox seashell (*Pleuroploca filamentosa*) at Nasipit River, Barangay Adlay, Carrascal, Surigao del Sur
MAC4	N 09.407160°	E 125.901700°	Interviewed gleaner coming from Purok - 6 Barangay Adlay, Carrascal, Surigao del Sur. Gleaned macro-invertebrates were: Pyram top shell *(Tectus pyramis*) "Tuwad-tuwad", Gold-mouth turban *(Turbo chrysostomus) "Takdagon"*, Venus clam *(Pitar herbraeus) "Buronay"*, and *(Vasticardium angulatum) "Litob"*.

Figure 2.2.50: Map showing the Location of Stations Surveyed for Presence of Macro-Invertebrates; 03-05 March 2021

Key respondents alleged that macro-invertebrates in the river estuaries have seriously disappeared in the last three years when sedimentation of river beds increased. At present, only few, non-target species of gastropods were observed in the survey stations. These include the costate nerith (*Nerita costata*), swamp cerith *Terebralia sulcata*, rayed pearl oyster *Pinctada imbricate (talabang bato),* tree oyster *Atrina vexillum (baloko),* hammer oyster *Malleus sp (talaba), c*rass turban sea snail *(Turbo crassus), Punctate codakia (Codakia punctata)* and ark shell *Anadara antiquata (litob);* (**Plate 2.2.18**). In the marine station in Carrascal Bay, one fishers harvested about 50 pieces of the giant spider shell *Lambis truncata.* Four of these species are commercially important; with the spider shell as the most lucrative.

Note: Top row: oysters, swamp cerith and costate nerith. Bottom row: crass turban sea snail, Anadra antiquata and giant spider shell

Plate 2.2.18: Macro-invertebrate Catalogued in Four (4) Stations; 03 - 05 March 2021

A gleaner coming from Purok - 6 Barangay Adlay claimed that bivalves and gastropods have disappeared from the Adlau River. Previously, they were harvesting pyram top shell *(Tectus pyramisor* "Tuwad-tuwad"), gold-mouth turban *(Turbo chrysostomus; "Takdagon")*, Venus clam *(Pitar herbraeus; "Buronay")*, and ark shell *(Vasticardium angulatum; "Litob")* in the river estuary. This gleaner alleges that sediments causing turbidity in the river system has led to the disappearance of the macro-invertebfrates.

Findings from the survey of macro-invertebrates are displayed in **Figure 2.2.51**.

Figure 2.2.51: Highlights of Results of Macro-Invertebrate Survey; 03 - 05 March 2021

2.2.4.8 Presence of pollution indicator species

Corals require clear water with strong sunlight penetration and are normally affected by extreme turbidity and sediment intrusion. Branching and tabulate corals, including *Acropora spp* staghorn *Acropora* and *Montipora spp* species are usually the most vulnerable to progressive demise of coral planulae due to sediment blanketing.

Bivalves and Fish species – Microscopic phytoplankton and zooplankton supports the complex lower base of the marine food chain and their niche in the marine environment fuels productivity and diversity, and sustains fish and shellfish recruitment. Microscopic algae or phytoplankton form the base of the food web upon which most marine organisms depend; including most edible bivalves and fish in their early life stages. Bivalves have been used to determine biotoxin levels that can be harmful to humans if they are consumed indiscriminately. The bivalves in the general vicinity of the project site can therefore be used to determine biotoxin contamination in seawater. Marine fish species have not been used as indicators of pollution, except where biotoxins are involved (e.g. plankton-filtering fish species in PSP-affected areas). On the contrary, some species of fish have been used as "indicators" of a relatively good coral reef habitat and its ecosystem functions. In the case of the Alingating shoal and Adlay MPA, only (2) species of the butterfly fish *Chaetodontidae* have been recorded in the present survey, and this is indicative of a poor habitat. The loss of these species over time is indicative of a degrading benthic ecosystem. Periodic fish visual census in the reefs fronting the project site can be adopted as a useful tool in measuring any negative impacts on fish indicator species.

The plankton survey revealed that the coastal water fronting the proposed project is free from toxic algal species and the proliferation of plankton species that are known to trigger Harmful algal Blooms (HABs) are almost nil and currently does not pose a risk capable of enhancing algal blooms. Thus from the data obtained, the coastal waters is presently considered normal even as Bislig bay has had episodes of red tides in previous years. However, algal blooms are natural phenomenon and can be influenced by a number of factors. These include cultural eutrophication and hyper-nutrient loading from domestic wastes, unusual climatological conditions and transport of dinoflagellates through ballast waters and transfer of shellfish stocks, among others. Harmful algal blooms occur in some locations because of entirely natural reasons, while other HAB events occur as a result of human activities. While progressive research on the precise triggers of algal blooms have provided much needed information, the need to understand some basic causes and subsequently, adoption of precautionary measures are recommended.

The species identified in this sampling which is listed in IOC-UNESCO Reference List of Harmful Microalgae (Moestrup et. al 2009) were *Dinophysis* spp. and *Pseudonitzschia* spp. The *Dinophysis* species identified here as *D. caudata is* a toxic dinoflagellate capable of producing toxin associated with Diarrhetic Shellfish Poisoning (DSP) (FAO, 2004). Some species of *Pseudonitzschia* spp. are reported to produce toxins associated with Amnesic Shellfish Poisoning (ASP). The contribution of this genus to overall phytoplankton abundance was very low with a total density of 80 cells per liter (0.19% of the total composition).

No red tide episodes have been recorded in Carrascal Bay. Marine fish and shellfish species have not been used as indicators of pollution, except where biotoxins are involved (e.g. plankton-filtering fish species in PSP-affected areas). Apart from the few bivalves observed, there were no species of fish or shellfish encountered in the sampling stations that can be employed as indicators of pollution. Dead standing corals overgrown with algae appear to have been caused by the excessive sediment intrusion.

2.2.4.9 Threat to Existence and/or Loss of Important Local Species and Habitat

The overall result of the assessments indicate that the primary coastal impact area of the proposed project hosts a diverse array of coastal habitats and resources that are already heavily taxed from a range of stressors of anthropogenic origin. In the mouth of the Bay, the coral reef community and associated seagrass beds are vividly impaired due to sediment blanketing resulting to extensive loss of coral colonies. Yields from small-scale fisheries, as well as size and species composition, are deteriorating but the harvest from artisanal set nets still supply important fish food for many households.Gleaning for edible shellfish is no longer being undertaken in the inter-tidal areas fronting Barangay Adlay as yields have been progressively declining over the years due to overharvesting and sediments. Over the long term, it is evident that there is a need to improve, and thereafter maintain the integrity and resilience of the broader components of coastal ecosystem in the project site as these are essential in nurturing fish stock growth, maturation and recruitment. An increase in fisheries productivity will translate to a broad support for the project's mitigation initiatives to protect the resource base upon which its operation is significantly intertwined.

One major issue is sediment intrusion in coastal waters. It is imperative that efforts to mitigate siltation and marine pollution needs to be squarely addressed but the current point sources of sediments can be diverse and extremely far from the bay. While recruitment of corals is happening where substrates are firm and free from thick silt loads in the Adlay MPA, the degree of restoration of ecosystem functions will certainly take a long time and efforts to conserve ecological niches where growth, reproduction and recruitment can take place undisturbed, is of primary consideration. Along this line, it is evident that the further use of illegal fishing practices, as well as the issue of siltation, are major issues that needs to be addressed. Any improvement over time needs to be comparatively evaluated through consistent coral reef monitoring and fish visual census.

Mangroves are in a relatively healthy state but their distribution is sparse and are too far from the project site and are unlikely to be affected by issues potentially disturbing to mangrove trees. Nevertheless, mangrove resources need to be conserved as a strategy to reduce sediment intrusion into coastal waters. Granting that mangrove trees and the mud flats upon which they thrive are not physically disturbed, their contribution to coastal fisheries productivity as nursery grounds for many species of fish and crustaceans and in the export of nutrients that feed the lower base of the marine food chain can remain robust an can contribute significantly to fish population recruitment.

The plankton community in the area appears to remain stable and no persistent history of red tide episodes in Carrascal Bay has been experienced. However, this still requires that HAB-causing organisms needs to be constantly monitored in sampling stations and in bivalves where biotoxin levels can be detected.

Macro-invertebrates and inter-tidal crustacean and fisheries resources are unimpressive and it is not foreseen that the establishment of the project will result to the loss of shellfish resources but the project should nonetheless pursue initiatives to ensure sustainability of populations of commercially important macro-invertebrates near the project site, especially the edible bivalves. Macro-invertebrate populations are not anticipated to improve unless some forceful strategies to restore benthic ecosystem integrity are introduced over the long term.

2.2.4.10 Threat to Abundance, Frequency and Distribution of Species

Sediment Intrusion in Coastal Waters

Accelerated and excessive erosion will lead to coral polyp suffocation if silt and sediment streams reach coastal waters if adequate containment measures are not instituted. Depending on current streams and density of sediments, soils and silted plumes of run-off water can be deposited in the different segments of the receiving body of water, including in coral reefs found to be in relatively good condition in the Adlay MPA. If erosion will not be controlled effectively, the effect will be progressive siltation and impairment of coastal water integrity and invasion of reef and seagrass habitats. Deterioration of water quality will be basically induced by increasing turbidity as sediments get sequestered in the water column or get stirred up by strong wave action. The resultant decrease in photosynthetic function and primary production can have far reaching impacts on fisheries reproductive, decreased reproductive output, shortened larval duration and subsequently, low larval recruitment and survival. Moreover, such sediment streams will likely amplify coastal water turbidity, in the form of TSS and further reduce sunlight penetration into the water column. In extreme cases, turbidity will lead to reduced photosynthetic function which can affect microscopic primary producers of phytoplankton and dependent zooplankton communities, and depress seagrass and macrobenthic algae settlement. The most serious impact would be further smothering of coral reef patches and disruption in fish reproductive processes which can depress larval growth and recruitment.

To prevent and mitigate the occurrence of pronounced sediment streams, slicks of oil and grease, silt plumes and wastewaters from reaching the sea, the underpinning strategic consideration is to prevent potential damage in the narrow strip of fringing reefs in Adlay. Preventing disturbance to fish populations will be naturally inherent to such preventive strategies. This coral patch in the Adlay MPA shall be the main conservation focal area and will be preserved as a niche for coral recruitment and biodiversity values, enhanced through scientific and technical interventions to promote growth and recruitment. The physical structures and operational strategies to prevent such episodes are largely standard engineering facilities and adaptive measures that will be instituted in all phase of project establishment and operation. In particular, the project will establish a siltation control system consisting of a series of sabo dams, silt traps and sediment filters in successive and mutually-reinforcing pattern in order to ensure that such sediment-laden streams of water are filtered repeatedly. At main river outfall area, dual layers of silt curtains will be installed. Periodic environmental monitoring of TSS, turbidity and in general, sediment loads in the coastal waters in Adlay will be undertaken and measures to strictly enforce policies against disposal of ship bilge water will be enforced in project vessels, in consonance with oil and grease containment measures. In order to prevent intermittent oil spills from project facilities and to control its accidental spread, containment facilities, collection and retrieval measures will be established at the project's motor pool and disposal of used oil will be undertaken properly. Cleanup activities that focus on removing oil and oily debris from the project area will be undertaken forcefully. Clean practices will be an underpinning responsibility in all aspects of project operations.

Siltation in Streambeds

Excessive silt loads from mining areas can spill into waterways and eventually the three river systems near the project site, resulting to alteration of streambeds, fish and crustacean habitats. The introduction of disturbances – soil debris, wastes matter and substances spilled out of project facilities to which river organisms have had no previous exposure can significantly alter the habitat of river organisms and disrupt grazing and migration pathways leading to failure of recruitment. Breeding grounds can be lost irretrievably. The excessive silt and sediment intrusion and spills will be controlled through the establishment of diversion canals and silt ponds flocculation cells where sediments can be contained, collected and re-used. In addition, riverbank rehabilitation and stabilization of river banks will be pursued. Stabilization of all possible pathways of fugitive sediments and silt plumes will be undertaken and periodically checked.

Impacts of Sediments on Mangroves

It is unlikely that potential sediment and pollution issues from mining operations will be a threat to the existence of mangroves as these resources are a good distance away from the site and its root system are natural accretion-forming. Nonetheless, it is an advantage if the growth of mangrove trees as well as seagrass beds within the primary impact area in inner Carrascal Bay is protected as these plants are known to sequester sediments and help in filtering turbid waters. Ensuring the robust growth and survival of mangrove forests will be a long term strategic initiative of the 4DVDI by supporting mangrove reforestation and protection projects. The benefits of mangrove management will be felt over the longer term – and will redound to improvements in fisheries productivity and other non-direct benefits.

Impacts of Sedimentation on Fisheries

The impacts of sedimentation and other disturbances of anthropogenic origin such as vegetation clearing debris on mobile organisms such as fish would be localized, temporary and minimal because of the inherent ability of these organisms to avoid disturbance. Increased suspended sediment levels and turbidity generated by mining activities would cause adult fish in the area to migrate to other suitable areas. However, fisheries productivity, already suffering from declining catch rates, would be further affected. Smaller species that are unable to migrate may be chronically exposed to highly turbid waters and may suffocate as their gills become clogged with sediments. This impact is expected to occur within the radius of around 0.5 km from the spill area like river estuaries. Estuaries are particularly delicate as these are feeding grounds of small fish and crustaceans and may animals seek refuge near estuaries.

On the whole, coral reefs shall be protected by supporting efforts to prevent the use of destructive fishing practices in the area. Focal conservation areas where reproductive processes can occur unimpeded will be established with the help of the Fisheries and Aquatic Resource Management Council of Carrascal. The 4DVDI will support fisheries management and stock enhancement measures through collaboration with the local government and the Municipal Fisheries and Aquatic Resources Management Council in the implementation of an Integrated Coastal Resource Management Plan of the LGU. Support to local organized fisher groups for the implementation of better fisheries law enforcement, advocacy against irresponsible fishing practices and the implementation of fish stock enhancement measures to protect growth, maturation and recruitment will be equally supported by the project.

Increased Freshwater and Soil Run-Off

Construction of mining facilities may lead to increased freshwater run-off and soil spills into waterways. To mitigate the impact of siltation/sedimentation on nearshore coastal communities and habitats, project construction (*i.e.,* earth-moving activities) should be done during the dry months. The use of geotextile silt curtains may also be employed to minimize turbidity effects or to reduce the spread of turbid waters from the construction site that could adversely reach adjacent coral reefs in Adlay.

Turbid Waters and Plankton Communities

Studies on the temporal patterns of *Pyrodinium* dinoflagellate occurrence in many bays in the country indicate more pronounced patterns of blooming in areas that are hyper-nutrified which are exacerbated and induced more prominently after the onset of rains, during period of relatively lower seawater temperatures caused by stratification of water. True enough, records show that the occurrence of more HABs in the Philippines has been associated with the onset of the southwest monsoon. In this regard, increased nutrient loading through sediment transport can be a likely pathway for occurrence of HABs in the coastal impact area of the if suspended organic matter (OM) in sediment transport causes hyper-nutrient levels and eutrophication. The pollution of coastal waters is believed to stimulate bursts in populations of microscopic and macroscopic algae as various pollution-supplied substances fertilize the water column and bottom substrate and provide the nutrients that trigger algal bloom proportions. Because of this, harmful or toxic algal species become more abundant and more noticeable. According to some scientists, the nutrients that humans supply to coastal waters are delivered in proportions which differ from those that naturally occur, such that the species composition of the algae is altered by favoring certain groups better adapted to nutrient supply ratios. It is to be noted however, that because sediments serve as a sink for various nutrients, sediment-associated environmental problems is an issue that cannot be attributed to single point source alone but to a broad range of sources, in many instances, domestic wastewater from households, open latrines, fertilized croplands, watersheds and denuded mountain slopes. It likely too that organic matter from the project's facilities, including sediments during construction, can be a source of nutrient loading in nearshore waters. Nevertheless, planktons are resilient and will readily re-colonize seawater even in turbid conditions. More importantly, survey results do not show any indication that red tides may directly occur as a result of the many activities in the area.

2.3 AIR

2.3.1 Climatology and Meteorology

2.3.1.1 Local Climate

The climate at the project site falls under Type II category based on the Modified Coronas Climate Classification System of Philippine Climate (**Figure 2.3.1**). Type II climate is characterized by no dry season but with very pronounced maximum rain period from December to January.

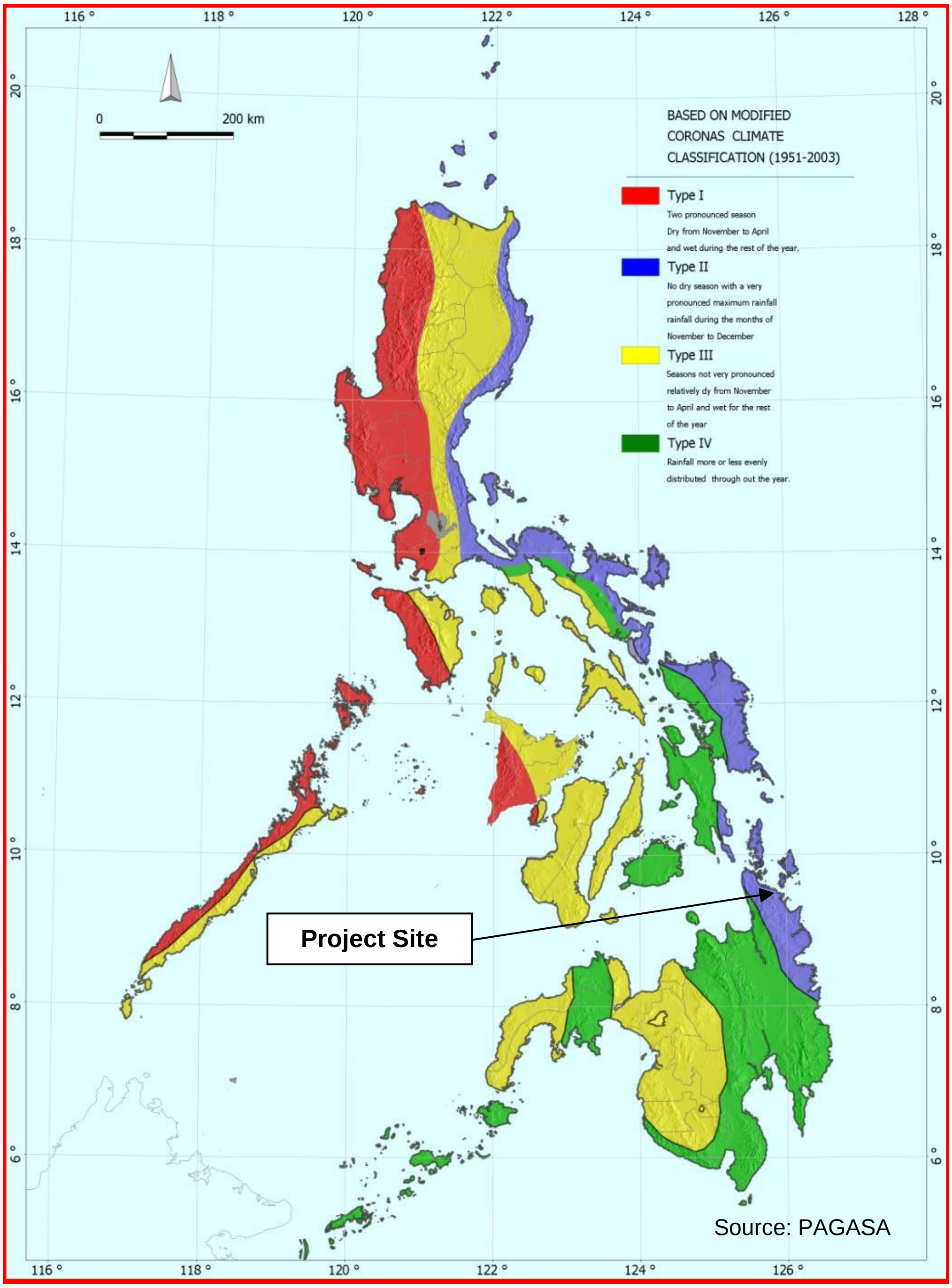


Figure 2.3.1: The Philippine Climate Map

2.3.1.2 Meteorology

The meteorological considerations at the Project site were described using the meteorological data from Surigao City PAGASA Synoptic Station. Meteorological data collected are from 1981-2010 with the following parameters: a) wind speed, b) wind direction, c) temperature (max, min, and mean), d) relative humidity, and e) rainfall data (**Table 2.3.1**).

Table 2.3.1: Climatological Normals Recorded at Surigao City PAGASA Synoptic Station (1981-2010)

Month	Rainfall Data		Temperature (°C)			Relative Humidity (%)	Wind Direction (16 pt)	Wind Speed (m/s)
	Amount (mm)	No. of Rainy Days	Max	Min	Mean			
January	609.4	26	29.4	23.3	26.3	88	NE	3
February	446.4	21	29.9	23.5	26.7	86	E	3
March	326	21	30.8	23.8	27.3	84	E	3
April	219.1	17	32	24.4	28.2	83	E	2
May	139.6	10	32.7	24.9	28.8	81	E	2
June	142.1	14	32.6	24.8	28.7	81	SW	2
July	171.1	15	32.3	24.6	28.5	81	SW	2
August	133.9	12	32.7	24.7	28.7	80	SW	2
September	171	15	32.7	24.6	28.7	80	W	2
October	240.7	19	32	24.4	28.2	82	W	2
November	467.3	22	30.8	24	27.4	86	E	2
December	585.2	25	29.9	23.7	26.8	87	NE	2
Annual	**3,651.8**	**220**	**31.5**	**24.2**	**27.9**	**83**	**E**	**2**

Source: Surigao City PAGASA Synoptic Station

Table 2.3.2: Climatological Extremes Recorded at the Surigao City Synoptic Station, Surigao del Norte as of 2014

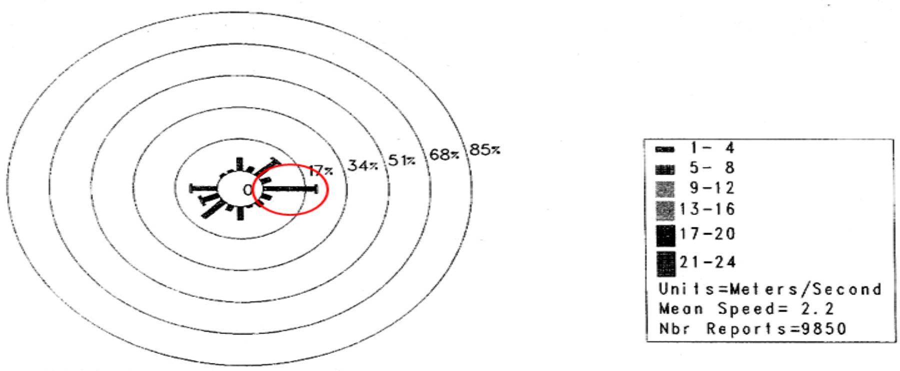
Month	Temperature, 0C				Greatest Daily RF, mm		Highest Wind Speed		
	High	Date	Low	Date	Amount	Date	Speed	Direction	Date
Jan	33.7	15-16	18.6	02-78	351.8	24-63	25	N	24-75
Feb	33.3	02-06	18.2	24-05	472.9	12-74	20	NE	21-97
Mar	3.0	31-39	18.8	01-49	237.5	19-59	29	NW	03-67
Apr	35.2	19-87	18.9	05-63	339.0	05-86	35	WSW	04-94
May	36.3	22-87	20.8	18-72	198.1	16-62	36	SSE	07-54
Jun	37.5	15-87	20.7	13-65	235.3	29-70	22	SSW	30-70
Jul	36.2	31-16	20.0	06-61	201.9	01-52	31	WNW	02-52
Aug	37.0	19-16	20.0	22-93	166.4	24-13	25	WSW	17-86
Sep	37.2	16-87	20.6	01-66	179.4	01-84	60	ENE	01-84
Oct	35.6	11-05	20.5	16-06	320.6	13-19	30	W	23-88
Nov	36.5	22-10	19.4	10-13	564.7	18-68	46	WSW	18-68
Dec	34.6	18-05	19.1	21-25	566.4	18-03	56	E	21-86
Annual	**37.5**	**15-87**	**18.2**	**24-05**	**566.4**	**18-03**	**60**	**ENE**	**01-84**
Period of Record	1903-2012				1902-2012		1950-2012		

2.3.1.2.1 Wind Regime

Based on the records of Surigao City Synoptic Station, data on local winds shown in **Table 2.3.1** indicates a general direction of east to northeast from November to May and west to southwest for the rest of the year. The wind pattern in the locality follows generally the wind regime of the country which is northeast monsoon from November to May and southwest monsoon from June to October. The wind speed at 10 meters above ground varies from two to 3 meters per second (mps) only. On extremes however, the wind speed can reach up to 56 mps.

The diagram of the wind pattern in Surigao Airport Synoptic Station is shown in **Figure 2.3.2**. The predominant wind direction does not follow the monsoonal winds and comes mostly from the east (easterlies). If this wind direction prevails over the mining area, the community will be safe from the dispersion of particulates coming from the mine site and hauling roads. The land-sea breeze may however prevail, but the community will be relatively safer regardless of which breeze will prevail.

WIND ROSE DIAGRAM, 1981-2010
SURIGAO CITY
Annual



FREQUENCY TABLE
Surigao City
Wind Speed and Direction
Annual (1981-2010)

Speed (mps) \ Direction	N	NNE	NE	ENE	E	ESE	SE	SSE
CALM								
1-4	7.0	2.7	11.3	3.7	21.0	4.3	2.7	1.4
5-8	0.3	0.2	1.2	0.5	0.6	0.1	0.0	0.0
8-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	7.3	2.9	12.5	4.2	21.6	4.4	2.7	1.4

Speed (mps) \ Direction	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
CALM									0.3
1-4	7.5	3.0	11.9	7.3	9.9	0.2	0.5	0.6	95.2
5-8	0.0	0.0	0.2	0.6	0.6	0.0	0.0	0.0	4.4
8-12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
13-16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	7.5	3.0	12.1	7.9	10.5	0.2	0.5	0.6	100.0

Climate and Agromet Data Section, CAD, PAGASA CY2013

Figure 2.3.2: The Wind Pattern in the Surigao City may also Represent that of Carrascal

2.3.1.2.2 Rainfall

Since it is the nearest, the synoptic station in Surigao City was used in assessing the rainfall data in the area. It is also located in the same climate type where the project is sited and has an extensive record dating back to 1971 without data gaps. During the wetter months (October to April), rainfall depths recorded range from 236.3 mm to 600.0 mm (**Table 2.3.1**). The lower limit is in the month of April while the upper limit is in the month of January. January therefore is the rainiest month.

In some instances, a daily extreme surpasses that of the monthly mean. The extreme 24-hr value recorded at the synoptic station is 600mm (09-01-1970), as presented in **Table 2.3.2**.

2.3.1.2.3 Temperature

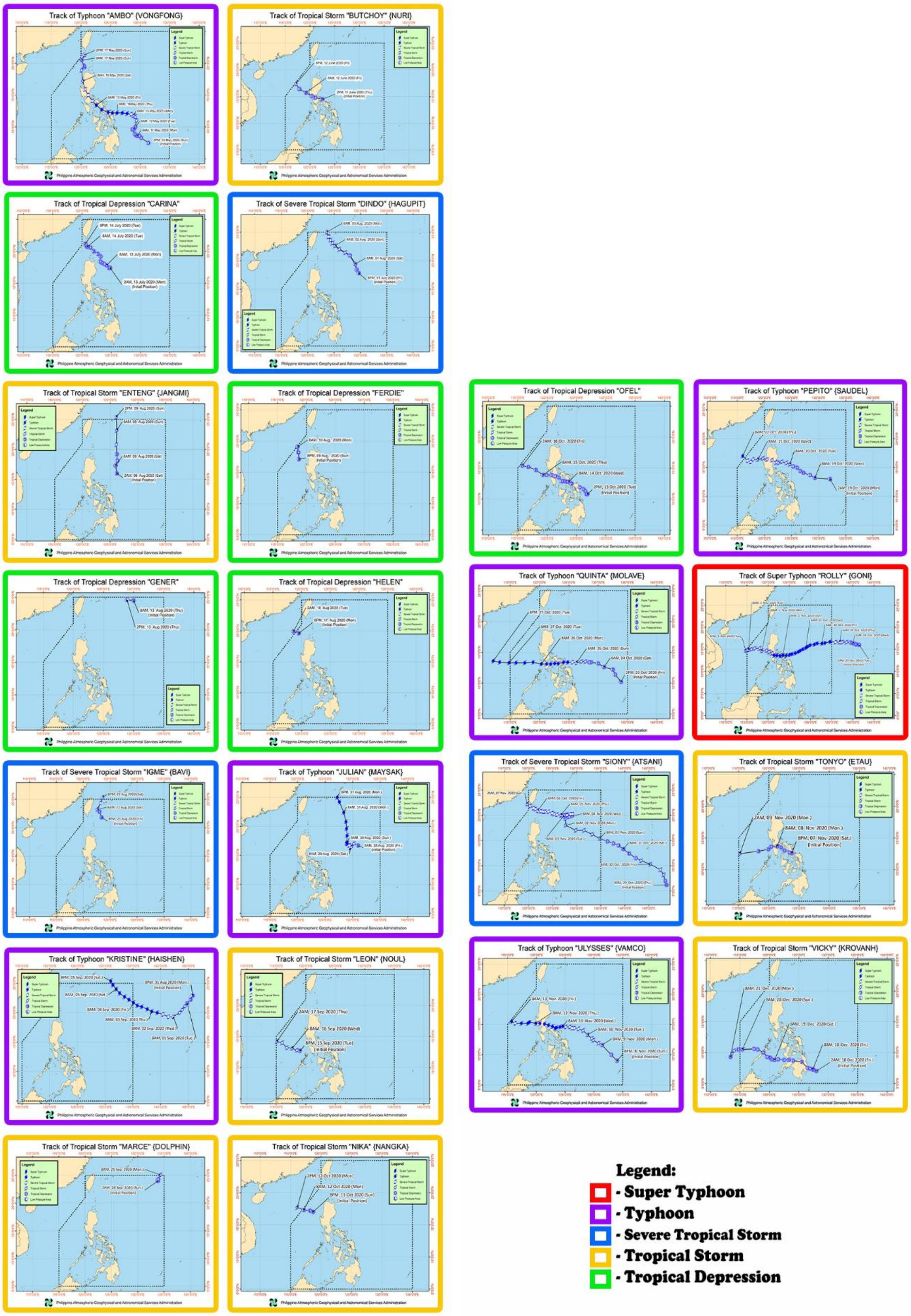
The temperature in the area varies from a minimum of 22.7°C to a maximum of 32.6°C (**Table 2.3.1**). The annual mean is 28 °C. March, April and May are the months that registered high temperature values suggesting of a warm weather condition. A cold period runs through December, January, and February when temperature values are low. On temperature extremes, the warmest recorded was in 17 May 1915 at 38.6 °C while the coldest was in 1 January 1914 at 14.5 °C (**Table 2.3.2**).

2.3.1.2.4 Cyclone Frequency

A tropical cyclone reaching maximum sustained winds of greater than 118 kph are called typhoons. The Philippines is located in the northwest Pacific Ocean cyclone basin and tropical cyclones. The greatest number of cyclones in the Philippines occur during the months of June to December. These tropical cyclones are associated with the occurrence of low pressures areas (LPA) normally originating over the North Western Pacific Ocean side of the Philippine Area of Responsibility (PAR) and generally moving northwestward. PAGASA categorized these cyclones as Super Typhoon, with sustained winds equal or up to 220 kph; Typhoon with sustained winds from 118-220 kph; Severe Tropical Storm with sustained winds from 89-117 kph; Tropical Storm with sustained winds from 62-88 kph; and Tropical Depression with sustained winds less than or equal to 61 kph. For the past 10 years the Philippines experiencing number of extremely damaging tropical cyclones. In May 18, 2015, PAGASA updated the tropical cyclone classification system for the Philippines. The new public storm warning signal system are as follows:

PSWS No. 1 – tropical cyclone winds of 30-60 kph; expected within the next 36 hours
PSWS No. 2 – tropical cyclone winds of 61-120 kph; expected within the next 24 hours
PSWS No. 3 – tropical cyclone winds of 121-170 kph; expected within the next 18 hours
PSWS No. 4 – tropical cyclone winds of 171-220 kph; expected within the next 12 hours
PSWS No. 5 – tropical cyclone winds of more than 220 kph; expected within 12 hours

Typhoons can be devastating to communities if directly hit. Strong winds can damage houses and even buildings made of strong materials and can blow away those made of light materials. Crops may suffer tremendous damage and other properties may be lost. If the typhoon brings about heavy rains extensive flooding may be produced and further the lives of affected miserable. Carrascal including the project site is susceptible to super typhoons due to its geographical location which is directly facing the Pacific Ocean where genesis of typhoons take place.



Source: PAGASA

Figure 2.3.3: 2020 Tropical Cyclone Tracks

2.3.1.3 Climate Risk/ Climate Change

2.3.1.3.1 Temperature Change

The PAGASA published a climate change scenario for the Philippines in February 2011. Under the published climate change scenario, the Province of Surigao del Sur will have an increase in temperature in 2020 and 2050. **Table 2.3.3** show the seasonal temperature increase in 2020 and 2050 under medium range emission scenario in the Province of Surigao del Sur.

Table 2.3.3: Seasonal Temperature Increase (in °C) in 2020 and 2050 under Medium Range Emission Scenario in the Province of Surigao del Sur

Observed Baseline (1971-2000)				Change in 2020 (2006-2035)				Change in 2050 (2036-2065)			
DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
26.4	27.4	27.9	27.4	0.9	1.0	1.1	1.1	1.7	2.0	2.3	2.0

The projected temperature increase is 0.9 to 1.2°C in 2020 and an increase of 1.0 to 2.2°C in 2050 from the observed baseline data (1971-2000). With these projections, the project site may experience temperature rise of 29.0 covering the period of 2006-2035 and 30.2 covering the period of 2036-2065 as shown in **Table 2.3.4**. **Figures 2.3.4** and **2.3.5** present the projected monthly average temperature with climate change (Tave CC) and without climate change (Tave base).

Table 2.3.4: Projected Seasonal Mean Temperature in 2020 and 2050 under Medium Range Emission Scenario in the Province of Surigao del Sur

Quarter	DJF	MAM	JJA	SON
Observed Baseline (1971-2000)				
Mean	24.2	26.5	25.9	25.6
With Climate Change Scenario (2006-2035)				
Mean	27.3	28.4	29	28.5
With Climate Change Scenario (2036-2065)				
Mean	28.1	29.4	30.2	29.4

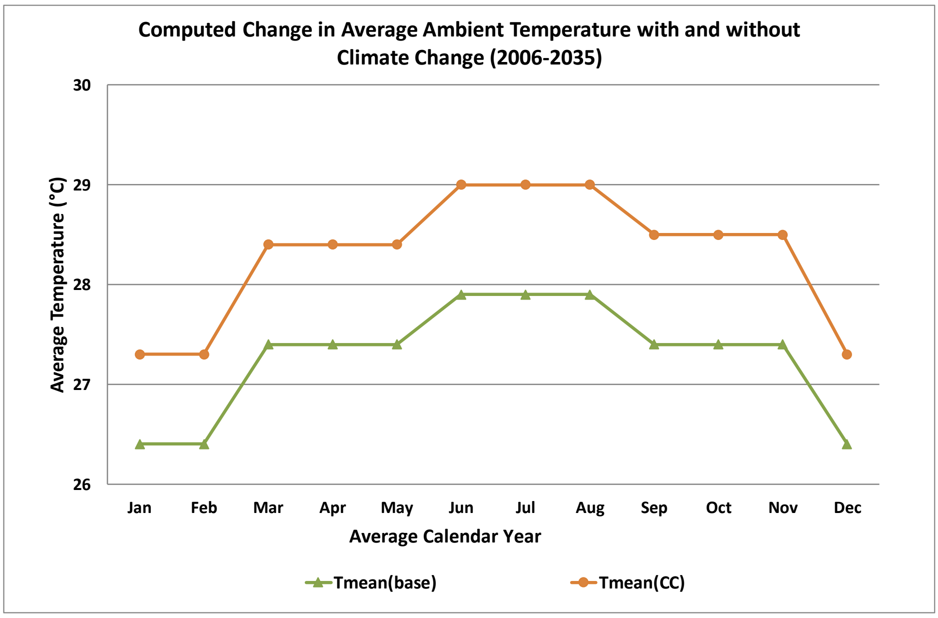


Figure 2.3.4: Change in Monthly Average Temperature for the Period 2006-2035

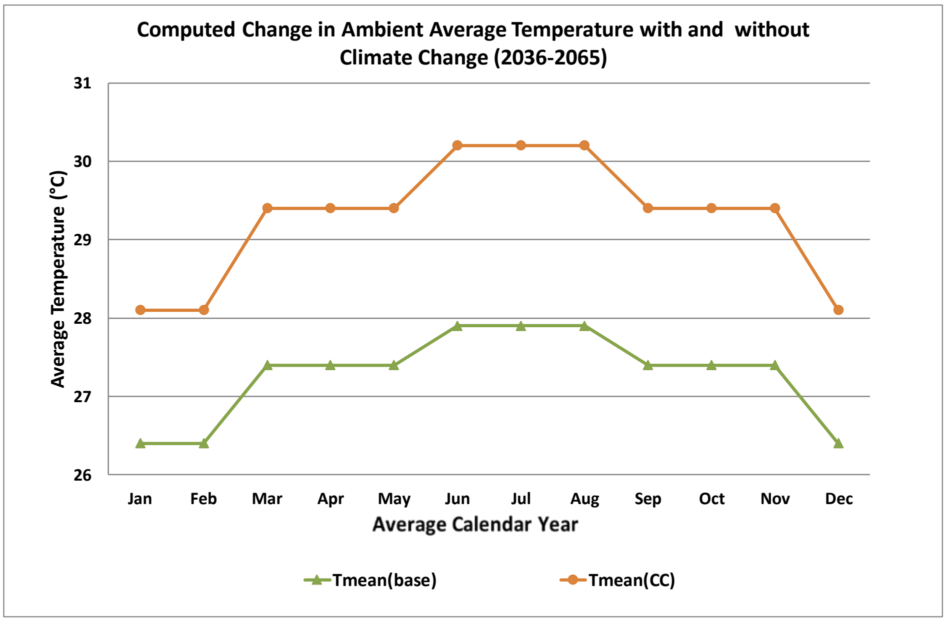


Figure 2.3.5: Change in Monthly Average Temperature for the Period 2036-2065

2.3.1.3.2 Rainfall Change

The PAGASA projection under medium range scenario in the province of Surigao del Sur showed a rainfall decrease and increase in 2020 and 2050 from the observed baseline data. **Table 2.3.5** present the seasonal rainfall change under medium range scenario.

Table 2.3.5: Seasonal Rainfall Change (in %) in 2020 and 2050 under Medium Range Emission Scenario in the Province of Surigao del Sur

Observed Baseline (1971-2000)				Change in 2020 (2006-2035)				Change in 2050 (2036-2065)			
DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
1394	746.9	534.6	842.5	5.8	-11.7	-2.2	-4.8	4	-29.1	-7.9	-3.7

In 2020, a rainfall increases of 5.8% is projected for months of December to February while a decrease of 11.7%, 2.2%, and 4.8% is projected for the months of March to May, July to August, and September to November, respectively. Similarly, the 2050 projection has an increase of 4% for the months of December to February while a decrease of 29.2%, 7.9%, and 3.7% for the months of March to May, July to August, and September to November, respectively. With these projections, the project site may experience a rainfall increase in the months of December to February and a rainfall decrease in the months of March to November.

Table 2.3.6: Projected Seasonal Mean Rainfall in 2020 and 2050 under Medium Range Emission Scenario in the Province of Surigao del Sur

Quarter	DJF	MAM	JJA	SON
Observed Baseline (1971-2000)				
Mean	1394	746.9	534.6	842.5
With Climate Change Scenario (2006-2035)				
Mean	1474.9	659.5	522.8	802.1
With Climate Change Scenario (2036-2065)				
Mean	1449.8	527.3	492.4	811.3

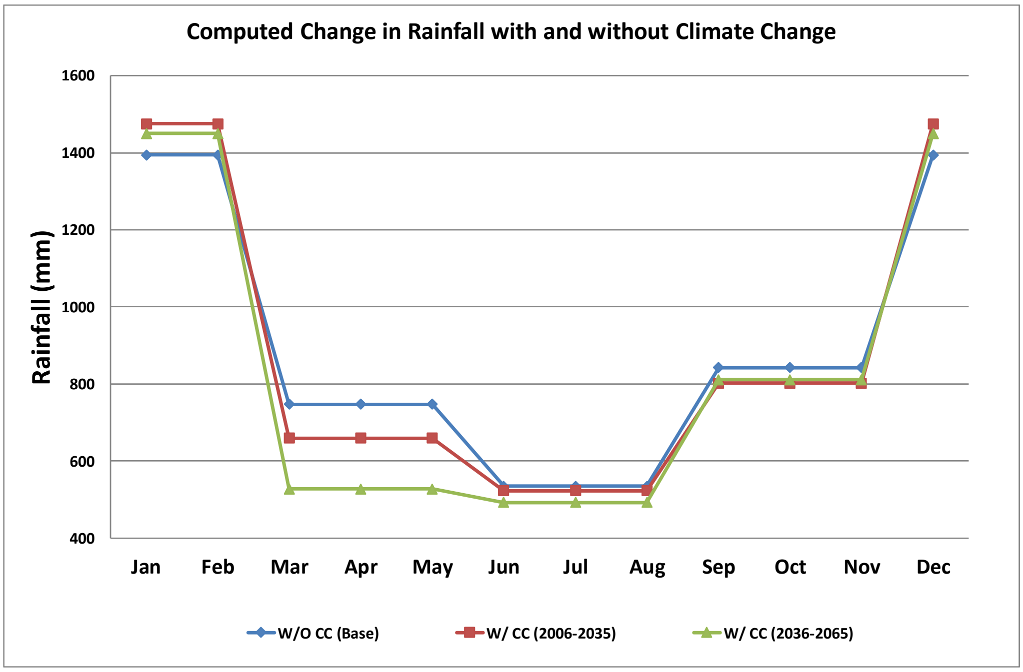


Figure 2.3.6: Projected Seasonal Mean Rainfall in 2020-2050

2.3.1.4 Contribution in Terms of Greenhouse Gas Emissions

One of the most important environmental changes now in progress is a build-up of atmospheric carbon dioxide (CO_2). Undoubtedly, the added CO_2 in the atmosphere is coming from the burning of fossil fuels, the cutting of forests, and the wastage of soil humus (the colloidal organic complex in the soil). The main outcome of the build-up is likely to be a climate change, notably toward greater warmth. The atmospheric CO_2 content is usually measured in terms of its concentration relative to all other gases in parts per million by volume (ppmv).

The GHG emissions from the project include carbon dioxide, methane and nitrous oxides. Calculation of these GHG emissions employ the Tier 1 Approach of the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines. This method calculates the GHG emissions from all sources of combustion and indirect off-site sources on the basis of the quantities of fuel consumed and average emission factors. The following equation was used:

$$CO_2 \text{ emissions} = FC \times NCV \times CEF \times FC \times K$$

Where: FC	=	Fuel Consumption, MT
NCV	=	Net Calorific Value, Tj/MT
CEF	=	Carbon Emission Factor, MT C/Tj
FC	=	Fraction Carbon Oxidized
K	=	*Molecular Weight Ratio of CO2 to C, (44/12)*
A	=	Fuel Type

The CO_2 emissions of the project were released from the exhaust tailpipe of trucks, heavy equipment, and other vehicles plying in the mining area. **Table 2.3.7** presents the amount of CO_2 emitted from the exhaust tailpipe for each liter of fuel.

Table 2.3.7: Tailpipe Emissions/Liter of Fuel Consumed

Fuel Type	CO2 Emissions, (kg/L)
Petrol	2.3
LPG	2.6
Diesel	2.7

Source: Department of Sustainability, Environment, Water and Population Communities, Australia

Assuming the project activities will deploy 50-units 30-tonner trucks, 10-units heavy equipment, 20-units service pick-up, and 10-units service vans. By using the data in **Table 2.3.7**, the estimated total CO_2 emission is 528,831.60MT/yr, as described in **Table 2.3.8**.

Table 2.3.8: Calculated CO_2 Emissions

Emission Sources	No. of Units	Fuel Type	Fuel Consumption (L/km)	Assumed distance travelled (km/yr)	Emission Factor (kg/L)	Calculated CO2 Emissions (MT/yr)
Heavy Equipment	10	Diesel	30	5,000	2.7	40.50
30-Ton Truck	50	Diesel	30	15,000	2.7	607.50
Pick-up	20	Diesel	20	12,000	2.7	129.60
Van	10	Diesel	20	10,000	2.7	54.00
Total CO2 Emission (MT/yr)						831.60

The estimated CO2 emission based on IPCC 2006 and United States Environmental Protection Agency (USEPA) is 136,175.33 metric tons per year. The Philippines Initial National Communication on Climate Change has projected 122,344 Gg of CO2 for 2008 for energy sector (**Table 2.3.9**). Using these projections of INC, the Project is expected to contribute approximately 0.43% of the total CO2 emission. In the global level projection of CO2 emission for 2020 under the USEPA Sectoral Trend in Global Energy Use and Greenhouse Gas Emissions, Climate Protection Division, Office of Air and Radiation, the estimated contribution of the Project is only 0.00585%. Therefore, the Project can still be considered as a low-end greenhouse gas emitter in the world.

Table 2.3.9: INC/SNC Data

Year	Gg CO2/yr	GHG %
Global Level[a]		
2000	6,118,000	0.00864
2010	7,936,000	0.00664
2020	9,042,000	0.00585
Energy Sector		
SNC		
2000	69,667	0.75908
2020	100,402	0.52671
INC		
INC Projected 2008	122,344	0.43225

Note: a – Sectoral Trend in Global Energy Use and Greenhouse Gas Emissions, Climate Protection Division, Office of Air and Radiation, US EPA, 2006
INC – Initial National Communication on Climate Change
SNC – Second National Communication on Climate Change

2.3.2 Air Quality

2.3.2.1 Ambient Air Quality

The project site's only source of air pollutants are vehicles plying the national highway and the feeder roads. But even then, the frequency of vehicular traffic is very light and the air shed is quite large enough for the dispersion of pollutants that can substantially reduce their concentrations. However, since the company started its operation on the basis of the small-scale mining permits, dust generation had been extensive especially along the roads where numerous dump trucks pass through where dusts generation directly affects the community.

To determine the baseline data on ambient air quality at built-up receptors, sampling activities were done in the barangay halls of Adlay and Pantukan and at the identified intersection of the causeway road and the national highway in Nasipit where the greatest number of hauling trucks are expected to converge (**Plates 2.3.1** to **2.3.3**).

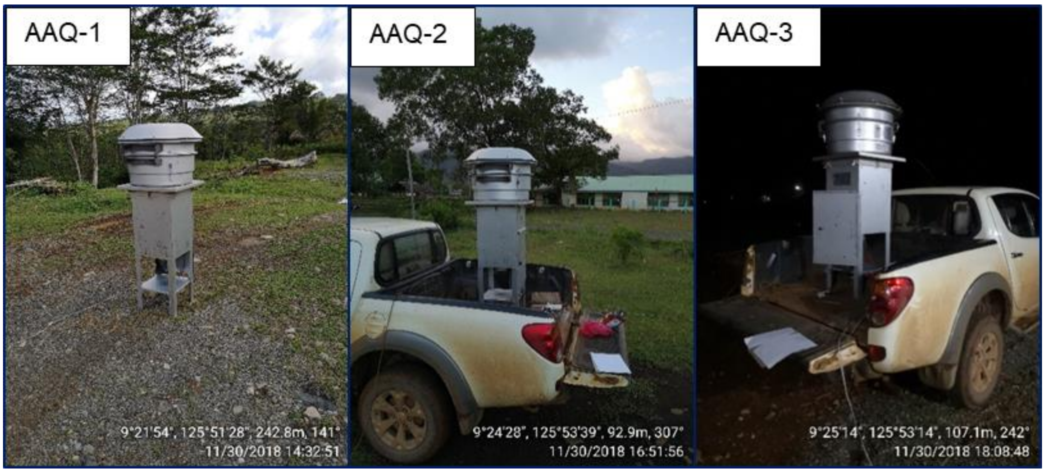


Plate 2.3.1: Pictures of the Conduct of PM10 Sampling dated November 30, 2018

Plate 2.3.2: Collection of Ambient Air Quality Samples at the Possible Community Receptor in Barangay Pantukan

Plate 2.3.3: Collection of Ambient Air Quality Samples at the Possible Community Receptors (NDCA-1, upper left) in Adlay, Carrascal, SDS and in a small community (upper right and lower photos) in Nasipit, Adlay, Carrascal, SDS

PM10 monitoring was conducted last November 30, 2018 at the identified sampling locations. The purpose of ambient air sampling is to conduct baseline monitoring and to validate the PM10 results of the previous monitoring conducted by Berkman Systems.

During sampling, a portable weather station was established by the sampling team to collect meteorological parameters such as wind speed, wind direction, relative humidity, etc. which will be used in the characterization of baseline air quality. As shown (**Figure 2.3.7**), winds prevail westerly occupying 29% of the time. Strongest wind is from north-northeast followed by north and easterly occupying 16.5% of the time. The average wind speed is 1.96 m/s and calm condition is 0.0% of the time.

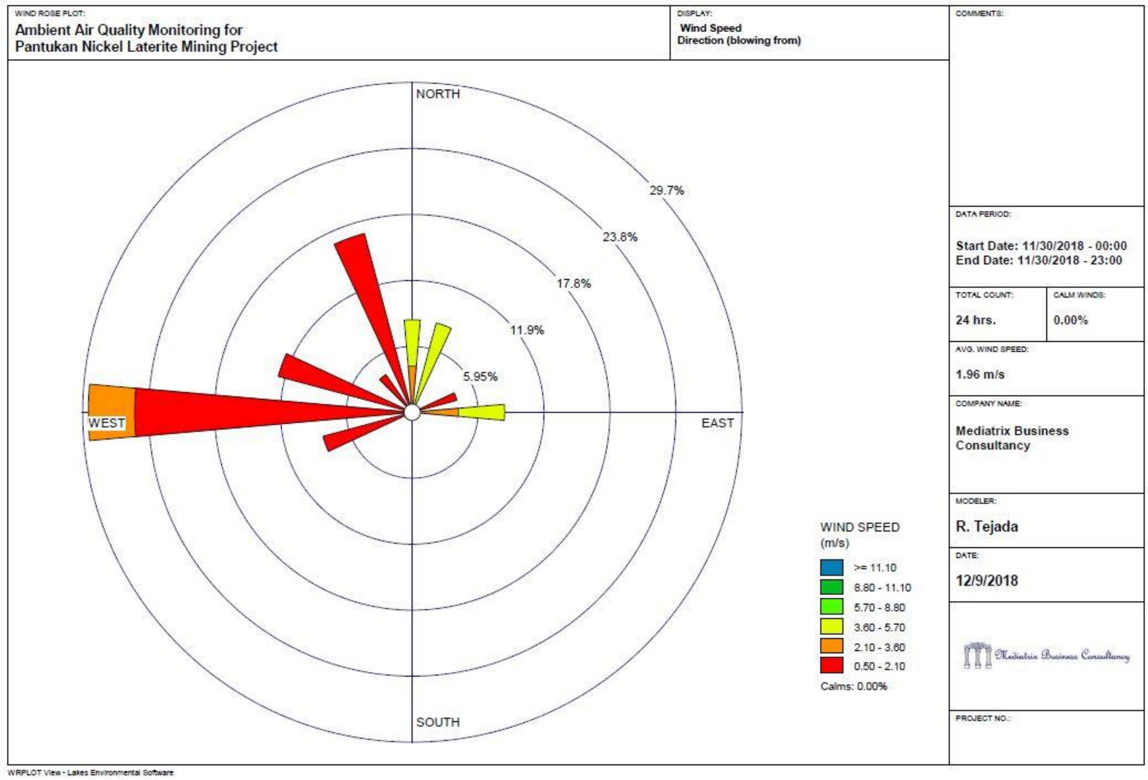


Figure 2.3.7: Windrose Plot for November 30, 2018

Results of the monitoring are tabulated in **Table 2.3.10**. PM10 in all sampling stations are below the CAA limit of 200 ug/Ncm. There was no observed major contributor to the air quality at AAQ-1 & AAQ-2, however in AAQ-3, major contributors are from mining trucks and other vehicles passing as the station is located approximately 20m away from the main highway (Surigao-Davao Coastal Road).

Table 2.3.10: PM10 Ambient Air Quality Monitoring Result

Station	Description	Date and Time of Sampling	Geographic Coordinates	PM_{10} Concentration (µg/Ncm)	SO_2 1 hr	NO_2 1 hr
AAQ-1	Inside the compound of Pantukan Barangay Hall	Nov. 30, 2018 1430H-1530H	9°21'54.0" 125°51'28.0"	4.17	5.8	1.8
AAQ-2	Approximately 50m away south of Adlay National High School	Nov. 30, 2018 1640H-1740H	9°24'28.0" 125°53'39.0"	21.72	8.2	0.7
AAQ-3	Approximately 20m away west of Surigao-Davao Coastal Road	Nov. 30, 2018 1800H-1900H	9°25'13.30" 125°53'14.29"	131.44	8.2	0.9
CAA Limit				**200**	340	260

2.3.2.2 Degradation of Ambient Air Quality

Dust can be generated during the extraction and hauling of ore but more pronounced in the latter. With increased activity particularly from hauling trucks passing non-cemented roads can yield so much dust that can be hazardous to workers. Dusts are expected to be experienced along the hauling route from the different stockpiles of the extraction areas down to the causeway. The sheer distance from the hauling route prevents the dusts to be dispersed into the community. However, the two types of breezes mentioned earlier can help suspend the particulates longer and travel the distance during nighttime when the wind direction would be from the hills to the coast or south to north, i.e., towards the community. In mining areas meanwhile, dusts can be generated by excavation and movements of heavy equipment including hauling trucks. Fugitive dusts can create an environment that is not only annoying to workers but a potential health risk as well. Workers here will be continuously exposed to particulates that are possibly contaminated with certain amount of natural asbestos. The asbestos is contained in the serpentinite or/and serpentinite peridotite specifically from their mineral component called chrysotile or antigorite.

The most effective way to controlling the lifting and suspension of dusts or particulates is to wet them thereby making them heavy for wind to carry. There must be a good number of spray or sprinkle trucks that will cover the hauling route and the highway. Frequency of water spraying is dependent on the activity in the area and the weather conditions. When ship loading is occasioned on a dry period, heavy traffic volume is expected and hence, dust generation will be extensive. In this case, spraying of roads will be frequent that a good number of water trucks will be needed. It is important that the hauling route should always be wet throughout the duration of the hauling activity. Road surfacing using uniformly graded base course can further reduce the amount of dust that can be lifted by hauling trucks. On the other hand, miners, drivers and other personnel involved in mining and hauling shall be required to use dust masks to prevent inhalation of dust that can possibly contain asbestos. This is an additional precautionary measure because wetting can already prevent lifting of dusts.

Another method to suppress dust generation is to apply on the road magnesium chloride ($MgCl2$) to agglomerate the dust particles and harden the surface. This should reduce the amount of dust generated and thereby assuring further the community from dust encroachment of their residences and even on their crops. However, care must be observed as this may create another environmental problem. This has to be studied very thoroughly.

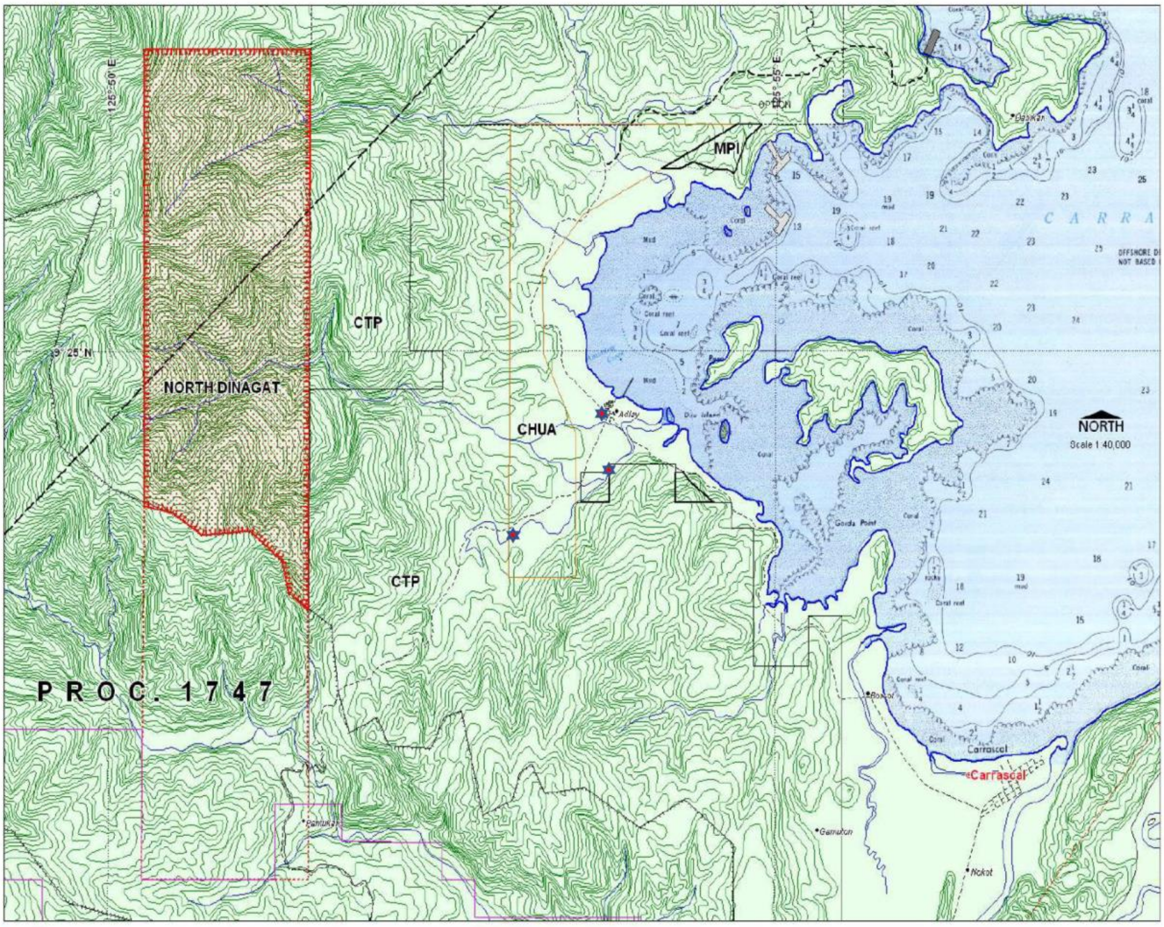
Aside from dust, NOx and SOx can also be generated from mining equipment and hauling trucks. The concentration will actually depend on how frenetic the operation could proceed and how the heavy equipment congregates. Where there is continuous production and traffic volume is high, the concentration can be significant at close distances. This is adversarial to the workers' health and needs to be addressed appropriately. Even residents living along the highway where support activities necessitate the use of a number of trucks, are also exposed to such pollutants although this is minimal due to a low traffic volume.

All equipment shall operate in tip-top condition. A self-monitoring system should be adopted by the company to make sure that the equipment used by contractors are not pollutive. The EMB Region 13 can be contacted for this purpose. That equipment that fail the tests shall not be allowed to operate until the engines had been tuned up and their emissions met the standards set by DENR.

2.3.3 Noise

2.3.3.1 Ambient Noise Level

Ambient noise was measured using a sound meter from a professional version of Smart Tools, an app that runs on android phones. The sound meter uses the microphone of the smart phone and displays the minimum, mean and maximum noise values and also the last value when the observation is stopped. The sound meter was calibrated with a standard noise meter manufactured by Caltech. Three trials for each of the stations were used and the average determined for the purpose of this study. The sampling stations are shown in **Figure 2.3.8**.



Sampling station

Figure 2.3.8: Location Map of Air Quality and Noise Sampling Stations

The results are presented in **Table 2.3.11**. The ambient average ranges from February 14 to 46, 2016. On many occasions, the readings spiked during the passing of vehicles particularly motorcycles and of noisy groups of individuals and from other sources. **Plate 2.3.4** presents the screenshots of the actual readings of the noise level during the sampling.

Table 2.3.11: Ambient Noise Measured from the Same Air Quality Sampling Stations

Station	Location	Sampling Date and Time	Geographic Coordinates	Noise Level (dBA)		
				Min	Ave.	Max
N1	Pantukan Brgy Hall	Feb. 14-15, 2016 1126-1126 H	09° 21' 55.4" N 125° 51' 28.8" E	47.0	72.0	83.0
N2	Nasipit, Adlay	Feb. 15, 2016 1320-1420 H	09o°24' 48.8" N 125° 53' 30.0" E	35.7	73.0	83.3
N3	Adlay Brgy Hall	Feb. 15-16, 2016 1715-1815 H	09° 24' 29.0" N 125° 53' 47.0" E	37.0	64.7	77.7

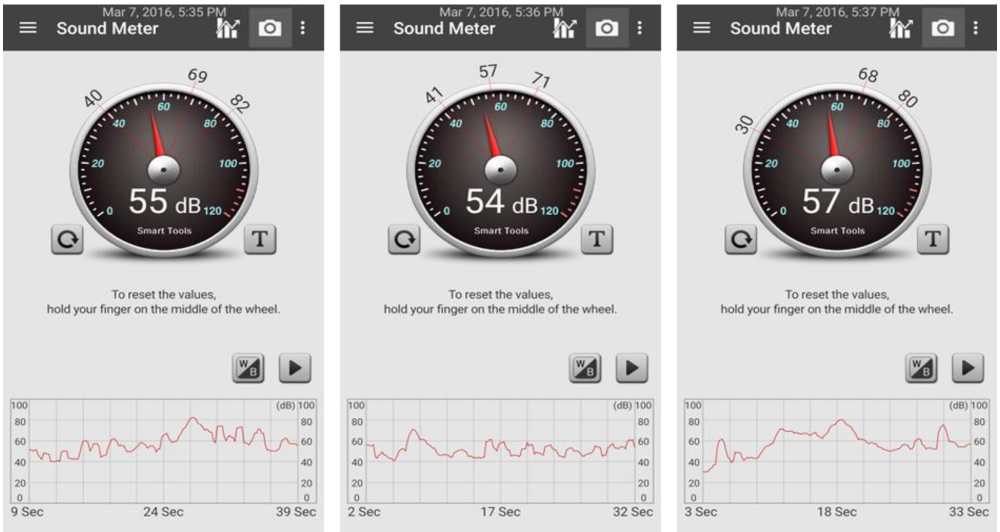


Plate 2.3.4: Screenshots of the Noise Level Readings at the Adlay Barangay Hall

2.3.3.2 Increase in Noise Level

Noise levels within the project site may increase substantially because of the introduction of different construction equipment. The sources of noise are bulldozers, payloaders, backhoes, graders, hauling trucks, generators, etc. **Table 2.3.12** shows the noise levels observed from various equipment at different distances. **Table 2.3.13** on the other hand, shows the permissible noise exposures times for occupational noise levels. The human ear can tolerate as much as 140 dB before experiencing pain (Rau and Wooten, 1980). Looking at both tables, all noises emanating from the listed sources can be well tolerated. But continuous exposure could be a nuisance to laborers and employees working close to the source of noise. Noise from mining and hauling in the MPSA area however will not affect the community because of the distance separating the two areas but future development may.

Table 2.3.12: Noise levels (in dBA) emanating from different construction equipment and measured from different distances

Construction Equipment	Distance from Construction Equipment (meters)			
	30	60	120	240
Backhoes	65-87	59-81	53-75	47-69
Compactors	66	60	54	48
Bulldozers	72-89	66-83	60-77	54-71
Graders	62-65	61-63	59-60	57-58
Loaders	66-75	60-69	54-63	48-57
Trucks	62-75	56-69	50-63	44-47
Concrete mixers	69-82	63-76	57-70	51-64
Concrete pumps	76	70	64	58
Tractors	72-89	66-83	60-77	54-71
Generators	66-76	60-70	54-64	48-58
Pumps	64-84	56-78	50-72	44-66
Vibrators	62-65	61-63	59-60	57-58

Table 2.3.13: Permissible Exposure for Occupational Noise Levels

Maximum Duration per Day (hrs)	Sound Level (dBA)
8	90
6	92
4	95
2	100
1	105
½	110
¼ or less	115

All engine-ran equipment will be equipped with efficient mufflers to reduce the levels of noise emanating from their exhausts. Those operators exposed to the noises of their equipment shall be required to use ear mufflers.

2.4 PEOPLE

2.4.1 Demography

2.4.1.1 Population

Based on the 2015 Census of Population and Housing (CPH), the province of Surigao del Sur posted a total population of 592,250 persons. This is larger by 31,031individuals compared to its total population of 561,219 persons counted in the 2010 CPH. The increase in the population count from 2000 to 2010 translated to an average annual population growth rate (PGR) of 1.12 percent. This is higher than the 1.05 percent annual PGR of the province between the census years 1990 and 2000.

Fifty years ago, the population of Surigao del Sur was only 165,016 persons. This population size is less than one third of the population of the province in the 2015 CPH (**Table 2.4.1**).

Table 2.4.1: Total Population by Census Year in Surigao del Sur (2015 Census)

Year	Pop.	±% p.a.
1990	452,098	—
1995	471,263	+0.78%
2000	501,808	+1.36%
2007	541,347	+1.05%
2010	561,219	+1.32%
2015	592,250	+1.03%

Source: Philippine Statistics Authority

Average household size was 4.6 persons. The number of households in 2015 was recorded at 129,457 higher by 20,941 households compared with the 94,028 households posted in 2000. The average household size in 2015 was 4.6 persons, lower than the average household size of 4.87 persons in 2000 (**Table 2.4.2**).

Table 2.4.2: Number of households in Surigao del Sur

Censual Year	Household Population	Number of Households	Ave. HH Size
2015	590,641	129,457	4.6
2010	560,140	114,969	4.9
2000	501,136	94,028	4.3

There were 101 households per 100 occupied housing units. A total of 113,804 occupied housing units were recorded in the province of Surigao del Sur in 2010. This translates to a ratio of 101 households for every 100 occupied housing units, with 4.9 persons per occupied housing unit. In 2000, there were 102 households per 100 occupied housing units, and 5.4 persons per occupied housing unit.

2.4.1.2 Land Area

Surigao del Sur comprises 17 municipalities and two cities, further subdivided into 309 barangays. There are two congressional districts encompassing all cities and towns. **Table 2.4.3** summarizes the population density per town or city.

Table 2.4.3: Component municipalities and cities of Surigao del Sur

Municipality or City		District	Area	Population (2010)		Density	No. Of
			km²	No.	%	Ind/km²	Barangays
Barobo		2nd	242.5	43,663	7.8	180	21
Bayabas		1st	117.84	7,779	1.4	66	7
Bislig	*	2nd	331.8	96,578	17.2	290	24
Cagwait		1st	214.1	18,899	3.4	88	11
Cantilan		1st	240.1	30,231	5.4	130	17
Carmen		1st	160.01	10,287	1.8	64	8
Carrascal		1st	265.8	16,529	2.9	62	14
Cortes		1st	127.08	15 541	2.8	120	12
Hinatuan		2nd	299.1	38,731	6.9	130	24
Lanuza		1st	290.6	11,857	2.1	41	13
Lianga		1st	161.12	28,905	5.2	180	13
Lingig		2nd	305.17	31,544	5.6	100	18
Madrid		1st	141.2	14,888	2.7	110	14
Marihatag		1st	312.5	17,926	3.2	57	12
San Agustin		1st	277.28	20,655	3.7	74	13
San Miguel		1s	558	36,287	6.5	65	18
Tagbina		2nd	343.49	34,812	6.2	100	25
Tago		1st	253.28	33,993	6.1	130	24
Tandag	†	1st	291.73	52,114	9.3	180	21

Note: *Component City, † Provincial Capital and Component City

CARRASCAL's population is 22,479 as of 2015 according to the Philippine Statistics Authority (PSA).

Table 2.4.4: Population of the barangays in the municipality of Carrascal

Barangay	Population
Adlay	6,332
Babuyan	721
Bacolod	1,018
Baybay (Pob.)	1,527
Bon-ot	1,862
Caglayag	382
Dahican	866
Doyos (Pob.)	1,725
Embarcadero (Pob.)	645
Gamuton	2,171
Panikian	2,910
Pantukan	737
Saca (Pob.)	1,100
Tag-Anito	483

2.4.1.3 Gender and Age Profile

In Carrascal, Surigao del Sur, ages 1-14 constitute 33.53% of the total household population. This group considered as the young dependency rate of the town. On the other hand, productive population of the town accounted to 55.51% and this group represents the household population ages 15 to 54 years old. This is a productive population indicating higher number of labor force. Old population group ages 55 and above accounted to more than 10.96% of the total household population. In terms of gender population, male outnumber the females at a ratio of 1.08:1. Error! Reference source not found. details the number of males and females by age group.

Table 2.4.5: Population by Age Group and Sex in Carrascal

Age Group	Both Sexes	Male	Female
All Ages	22,404	11,633	10,771
Under 1	588	301	287
1 - 4	2,362	1,232	1,130

5 - 9	2,360	1,220	1,140
10 - 14	2,202	1,181	1,021
15 - 19	2,141	1,082	1,059
20 - 24	2,147	1,125	1,022
25 - 29	1,870	996	874
30 - 34	1,649	883	766
35 - 39	1,352	730	622
40 - 44	1,233	614	619
45 - 49	1,135	606	529
50 - 54	909	488	421
55 - 59	770	404	366
60 - 64	605	315	290
65 - 69	378	172	206
70 - 74	280	126	154
75 - 79	197	79	118
80 years and over	226	79	147

Source: Philippine Statistics Authority, 2015 Census of Population

In Claver, Surigao del Norte, more than 38% of the population or about 8,037 is considered as young dependents ages from under 1 to 14 years old and 5,331 of it are considered school going age (Error! Reference source not found.**2.4.6**). A total of 11,908 populations are considered p roductive ages between 15 to 64 years old which is about 56 percent of the total population. The old dependent population comprises 4 percent of the total population or at about 1,026 populations. This data was computed based on the prevailing NSO census count. CBMS record shows that there are about 3,469 children ages 6 to 12 which are the school going ages for elementary school level and 1,862 children ages 13 to 16 which belong to the secondary level school going age population (Error! Reference source not found.**2.4.7**).

Table 2.4.6: Population by Age Group in Claver

Age Group	Population
Under 1-4	2,694
5-9	2,695
10-14	2,648
15-19	2,235
20-24	1,716
25-29	1,415
30-34	1,290
35-39	1,235
40-44	1,055
45-49	848
50-54	759
55-59	753
60-64	602
65-69	372
70-74	276
75-79	189
80 and over	189

Source: MPDO

Table 2.4.7: Population by Household Age Group

Indicator Source: CBMS	Households		Population					
	M'tude	P'tion	Magnitude			Proportion		
			Total	Male	Female	Total	Male	Female
Population	4555		20970	10694	10276	100	51.0	49.0
Average household size	5							
Children 0-5 years old	1974	43.3	2967	1544	1423	14.1	14.4	13.9
Children 6-12 years old	2054	45.1	3469	1768	1700	16.5	16.5	16.5
Members 13-16 years old	1399	30.7	1862	965	897	8.9	9.0	8.7
Members 6-16 years old	2538	55.7	5331	2733	2597	25.4	25.6	25.3
Members 10 years old and above	4542	99.7	15985	8129	7855	76.2	76.0	76.5
Members of the labor force	3758	82.5	5760	4276	1484	27.5	40.0	14.4

2.4.1.4 Literacy Rate and Education Attainment

Carrascal has a 92% literacy rate. This means that 92% of the total population in the 10-year-old and above age bracket is capable of reading and writing. Illiteracy accounted for around 8% of the population in the same age bracket. In terms of gender more than 51% literate people are females. Spatially, there are more illiterates in the rural barangays than the urban barangays. Claver, on the other hand, has literacy rate of 90%.

2.4.2 Migration Profile

Though part of Cantilan in 1918, the town of Carrascal was considered as one of the most settled area of the province. Settlements accounted to 2,489 inhabitants in the 1903 census. Population rose up to 5,557 in 1939 posting a 2.25% average growth rate. Population of Carrascal continues to grow until it reached its highest historical mark in 1980 where at about 12,180 inhabitants were accounted for and the average growth rate reached 6.67%. From thereon, population assumed a downward trend due to the continued out-migration of the people to other towns and provinces seeking for better economic opportunities. In 2015, the town has an average growth rate of 1.8%. **Table 2.4.8** shows the incremental growth of population in Carrascal.

Table 2.4.8: Historical Growth of Population

Year	Population	Average Growth Rate
1903	2,489	-
1939	5,557	3.42
1948	5,988	0.86
1960	7,898	2.66
1970	8,240	0.43
1975	9,230	2.40
1980	12,810	7.76
1990	12,693	(0.09)
1995	12,018	(1.06)
2000	13,157	1.90
2001	13,394	1.80
2002	13,635	1.80
2003	13,880	1.80
2004	14,130	1.80
2005	14,384	1.80
2006	14,643	1.80
2007	14,907	1.80
2008	15,175	1.80
2009	15,448	1.80
2010	15,726	1.80
2015	22,479	8.59

The in-migrants will be coming from different regions whose culture may be different from those of the local communities. Through interaction, cultural adjustments may naturally follow but not always. This may take time and sometimes fraught with disenchantment, a condition that breeds animosity and eventually violence. This is normally expressed during drinking sessions.

With available money at hand, proliferation of vices that tend to undermine the morality of the people in the barangay, is expected. Videoke bars, clubs, gambling places, prostitution, and others can rise in due time when workers in the minesite could be attracted to such offering and indulge in activities that may destroy family values. Furthermore, drinking may result to the commission of crimes if not properly handled. It is anticipated therefore that social problems may arise as an aftermath of a fluid local economy.

To help the in-migrant workers assimilate with the culture of the local communities, the 4DVDI will initiate social gatherings where interaction with the local folks will be enhanced. Gender sensitivity, responsible citizenship and parenting roles will also be discussed. This will be studied by the community relations officer of the 4DVDI in order for her to come up with ideal social functions, sports competition, etc. that will promote adaptation to the local folks' way of life.

Proliferation of vices is quite difficult to control since businesses of this nature are regulated by the local government. The 4DVDI will however encourage prayer meetings and other related activities that will prevent the workers from going to places of vices and instead go to places of worship. Arrangement will be done with local religious groups to work up a strategy that will keep their values from degenerating. Sports development and competition will also be part of the social program of the 4DVDI.

2.4.3 Indigenous People

2.4.3.1 The Manobos of Carascal and Claver

The origins of the Manobo tribe can be traced way back in the early times from the migration of the early Malay people of South East Asia to the Philippine Islands. Historians often associate the origin of this indigenous group to the group of people who settled the archipelago long time ago. This group of people came from the neighboring countries in South East Asia. The first batch came in the islands as they look for temporary settlement traveling through land bridges as the Philippines is believed to be connected in the mainland Asia before (ice age). Early batches settled in the Philippines came from any were in south Asia with the marine vessels.

Manobo" or "Manuvu" means "person" or "people"; it may also have been originally "Mansuba" from man (person or people) and suba (river), hence meaning "river people." A third derivation is from "Banobo," the name of a creek that presently flows to Pulangi River about 2 km below Cotabato City. A fourth is from "man" meaning "first, aboriginal" and "tuvu" meaning "grow, growth. "Manobo" is the hispanized form.

The Manobo people usually engage in farming and agriculture for they live in the rural areas of Mindanao. This group is male dominated. The husband is considered as the head of the family and he is the one who made family decisions. Polygamy is being exercise except in some groups where polygamy is performed only by the royal blood like a powerful Datu or a Sultan (chieftain or headmen)

The upland Manobo practice swidden or slash-burn farming whereas those inhabiting the valleys practice wet-rice farming. Rice culture is so central to the Manobo way of life that there are more than 60 different names for rice varieties, and all agricultural rituals center on it. In the late 190s, however many Manobo groups shifted to corn culture because of the gradual disappearance of swidden sites. Besides corn grit, other supplementary foods are sweet potatoes and cassava. In times of famine, emergency foods are unripe bananas and wild yam. Other major means of subsistence are fishing, hunting, bee hunting, and trapping. Because of these occupations, the Manobo live a seminomadic life. However, some Manobo villages that have established permanent settlements have shifted to the cultivation of coconut for copra export.

The Agusan Manobo is one of eight (8) tribal groups that comprise a cluster of tribes known generally as Manobo, who inhabit the island of Mindanao in the Philippines. The Agusan Manobo number about 60,000 and live in the flood plains along the mighty Agusan River and adjacent foot hills of North Central Mindanao

Unlike other tribes of Mindanao who live in rugged, remote mountains, the Agusan River Manobo live in an area that annually becomes a vast inland lake. Some build houses atop tall wooden posts, while most build on large tree trunks lashed together and anchored so that they will float the 3-4 months of flood season. The religious beliefs of the Agusan Manobo are similar to most other tribal peoples of Mindanao that is that there are many unseen spirits who interfere in the lives of humans. They believe that these spirits can intrude on human activities to accomplish their desires. The spirits are also believed to have human characteristics. They are both good and evil in nature and can be evoked to both anger and pleasure. They to have a belief in one "great spirit", who is viewed as the creator figure.

The traditional social structure consists of four classes: the bagani, the baylan, commoner, and slave. The bagani class, now gone, defended the community and went to battle. The baylan, who can still be found, is a male or female priest and healer. The commoners were farmers; and the slaves, who had been seized in raids, belonged to the ruler and were usually given away as part of the bridewealth. Village members could also become enslaved if they could not pay the penalty for a crime they had committed, such as thievery, destruction of property, adultery, or verbal offense. Slaves, however could win their freedom through diligence in the fulfillment of their duties, faithfulness to their master, or payment of their debt through servitude. Slaves who were treated like members of the family although still in servitude are bilew, and it was considered an insult if they were referred to as slaves. One who did so was committing tempela, ridiculing someone for their low status physical handicap.

2.4.3.2 The Mamananwa of Carascal and Claver

Mamanuas, in the old Visayan language means 'going to town'. The ancestral people of several indigenous people in the Northern area of Surigao, Philippines dating back to the earlier centuries. The Mamanuas inhabit the mountains in North East Mindanao. They are a relatively small aboriginal tribe, perhaps numbering no more than 10,000. The Mamanuas are nomadic tribes. They are nomads who always transfer their habitats.

They are believed to be direct descendants of the raft-traveling Polynesians of the past days who were said to have traveled throughout the Pacific on the balsa-wood rafts. The Mamanuas could also be the early Micronesians that Dr. Feodor Jagor mentioned in the 19th century. Except for their brown skin, they resemble in looks to the Africans. Physically, they are bigger than the Negritos of Luzon, but their kinky hair gives the possibility of blood relations to the aforementioned groups of people.
The Mamanuas are lesser in number and more scattered and nomadic. The Mamanuas are a different breed of people in their looks and physical features compared to the lowlanders. They generally do not adopt the lowlanders' way of living even if they were already Christianized. They had been rooted for centuries in the indigenous culture which is very difficult to understand. They speak their own dialect which noticeably has some phonetic similarities with that of Surigaonon.

Some old Mamanuas of today tell of their ancestors' early habitats along river mouths, seashores, islets and islands. They cannot, however, pinpoint particular areas as their permanent settlements for they did not have any. They transfer from place to place and travel as far as their minds could imagine and their feet could carry them. The transfers usually happen in case of deaths for it was the old customs to pack up and leave the place when death occurs even if their plants are ready for harvest.

The Mamanuas of today, however, mix with the lowland people they call Bisayans. It is observed that both out-groups have trust and confidence with the lowlanders though shyness prevails in any deal they have with them. They have the characteristic habit of building constant and eternal fires at the sides or under their makeshifts. The purpose is to drive away mosquitoes and flies, their most dreaded insects. Until now, some Mamanuas still believe that flies bring bad omens. To them, these insects are harbingers and heralds of deaths as the old Mamanuas said. One of the causes of their being nomadic is the prevalence of flies.

Although the above custom is ebbing with the advent of Christianization, some still cling and adhere to the belief of building fires to drive the evil spirits away.

The Mamanuas are not fond of weaponries. They also seldom wear necklaces, armlets, and some other trinkets.

The Mamanuas are python meat-eaters. Bagging one of a sizeable python would mean a fiesta for the tribe and the neighboring tribal settlements, which could hear the beatings with messages of the agong. They congregate and partake of the commonly broiled or roasted python meat. (Python meat is a delicacy of the Mamanuas who are experts in trapping or killing this dangerous reptile.)

A big snake or python would also mean money for these people. Not a few lowlanders would by and eat python meat that the Mamanuas trap. Aside from the meat, the Mamanuas get the skin and bile of the reptile, the latter is used for medicinal purposes. And so with the extracted lard from the fatty meat. The Mamanuas are a respectable lot of people and their respectfulness is sometimes attributed by the ancient writers as a way of worship. They show respect on thing and places which are beyond their comprehensions. The sun, moon, stars, big rocks, mountains, rivers, seas and lakes have special places in the hearts and minds of the Mamanuas. Anything that gives goodness and food to them is to be respected. The lights from the heavenly bodies, the fishes from the waters, the big rocks that sometimes become their temporary homes in their nomadic lives are to be honored by them. The mountains that give them food like wild berries, fruits, birds, animals and reptiles are likewise given respect. For them, thing and places that are sources of foods seem to be gods.

The Mamanuas have a ritual for the full moon. From moonrise in the early disk to moonset till dawn, they dance and mumble their ethnic duplications. This moon dance is sometimes attributed by the lowlanders as the spirit dance.

The Mamanuas are known to have practice medications with the use of herbs. Roots, barks and leaves of trees and vines come in different forms for the cure of a variety of ailments that they suffer. Some of these medications are observed to be very effective. And these medicinal flora which still exist today. They have specific and effective herbal medicine for snake, scorpion and centipede bites. They have leaves from trees, shrubs, vines and grasses to be pounded or plastered to the body of a sick person. They have shrub leaves for toothaches, eye sty, bleeding nose, crumps, muscle pains, gas pains, acidity and almost any human disease. In beeswax gathering, an old livelihood that the Mamanuas have, they use some herbs to be rubbed all over their bodies before gathering the wax. The bees would not sting them because of the herbal repellants that would kill them.

The Mamanuas have many uses for the wax and honey, the latter they store in jars and then in bottles. The maggots and young bees that are still white are eaten by them for they believe that this will make them flighty, Spartan like and light-footed in their mountain travels. Honey is also use for treating skin disease and cosmetics for newly born children because they believe the honey-cosmetics would retain the kinkiness of their children’s hair.

The old Mamanuas are usually believed to be *tambajan* or medicine men. A *tambajan* is generally believed to be a charmer aside from being a simple herbal medicine man. The Mamanuas are also noted to have charms. They have a lot of charms for a variety of purpose.

These tribal medicine men are also said to have power which could kill a person through that latter’s footprints. Ordinarily, this power is a curse or an imprecation. The Mamanuas do not have a definite term for it.

There are no Mamanwas and Manobos residing in Barangay Cagdianao.

2.4.4 Historical and Cultural Heritage

2.4.4.1 Brief History of Carrascal

For the first time in 1879, Carrascal was mentioned in the chronicles of the Spanish Friary in Cantilan. Fr. Antonio H. Van Odkij, a missionary, noted that Carrascal appeared ready to be converted into a barrio or outstation like Panikian. This is 255 years back to the inception in 1624 of the Christianization of Ilihan and Dinayhugan in what is now Carrascal, and of Calagdaan, Palasao, and Bayuyo of the Cantilan side; and 85 years up to the conversion of Panikian as a "visita" of Calagdaan in 1709.

If we consider that Tandag had only 54 "tributantes" and some 200 inhabitants when she became that seat of the priory then administering Christianization of the region to Cantilan, we could visualize how very modest that fishing/farming village of Carrascal could be in 1879.

Viewed from another historical angle, the story of the development of the town of Carrascal dates back to two ancestor habits: Ilihan and Dinayhugan. Pastoral accounts in Cantilan showed evidence of Ilihan and Dinayhugan being confused for or as Panikian.

Situated at the foot of a mountain some seven kilometers to the southwest of the bay of Carrascal, Ilihan and Dinayhugan provided safe haven to their people from Moro marauders of the period like her contemporary habitats nearby in the flatlands to the east and sea, namely Calagdaan, Palasao and Bayuyo, their inhabitants were "Manobos" with sprinkling of other ethnic tribes. These were the heathens the Spanish Monks encountered when they came from halfway around the globe. Fr. Juan de San Antonio, a missionary, who stayed for two years in Calagdaan. Selfless and undaunted, the succession of friars introduced to the heathens a Supreme Being form who loves, cares, helps, protects and forgives - the very virtues the lowlanders never heard of before. Against their ethnic diwatas and gods, or against there each-one-to-himself culture. God's will prevailed.

Parish records in Cantilan were soon full of names of Manobos who embraced Christianity and gradually assimilated rudiments of civilization: living in settlement, farming, participating in socio-religious practices of the time and later on schooling. Round their habitats, their "baganis" took infinite pride and renown for being brave, killing brutes. In time this tribal traditions lapsed to limbo. Noteworthy, the entire Cantilan region stood blameless for no friars ever getting harmed; Tandag region recorded three.

It is interesting to note that while the habitats on the Cantilan side were able to progress while Ilihan and Dinayhugan on Carrascal side were gradually falling away from the mainstream of Christianization and development: Several factors are noted:

- Ilihan and Dinayhugan never recovered from the exodus of their Christianized population which was enforced by Fray Valero de San Antonio to beef up the new settlement he founded, which was to be known by the name Can Tilang (Daan Lungsod) situated across the river;
- Compounding the loss, Moro raids started to decline, rendering isolation a no-growth liability; and
- Panikian, closer to the farm and sea, attracted the leftover inhabitants, thereby completing the abundant of Ilihan and Dinayhugan. If Dinayhugan is remembered or visited at all, it is because of the cave nearby that holds large deposits of guano and the treasure trove of relics, fossils, artifacts and other anthropological curiosities including tell-tale remains of the ancient church.
- Aborted from her ancestral roots and with Panikian on the ascendant, Carrascal become a snail-paced developing satellite of new Cantilan. This Cinderella episode in the development of Carrascal was to last 40 years, into the end of 1919, when she became the municipality independent of mother town Cantilan.

Now Cantilan, founded 232 years later than Ilihan, was soon to become the seat of Christianization and development of the sprawling jurisdiction extending as far to the south as Lanuza. Winning special esteem and influence, first from Fray Valero and later Fray Modesto Marzo y Casabana, founder of New Cantilan 1856, the New Cantilan held a runaway consideration on the priorities of the development-oriented friary.

Beyond all this, though Carrascal held an ace vital to an economic and industrial world prominence. For her mass of mountains constitutes a world-class growth potential no other Philippine could similarly claim. This potential was discovered early in the inception of the American regime.

2.4.4.2 Brief History of Claver

Since the time immemorial the present site of Poblacion Claver was a virgin swampy land dotted with dry land called Claver in the dialect "Taposoc". The biggest dry land is now the Claver Sport Center site and the Roman Catholic Church yard, respectively. The said place is adjacent to a river, which was rich in marine products such as crabs, shrimps, shell and different fishes. In the different dry land spot grew big trees. Some of the trees bear edible fruits. Different kinds of birds built their nests in the trees making them as their permanent homes. That particular place was attractive for human beings to settle.

In 1900, during the beginning of the American Regime, the administration created many barrios into municipalities, and one of them was Claver. It became a municipality of the province of Surigao. Existence of being a municipality lasted only for five years, due to the epidemic that occurred in 1903, resulted in the deaths of several people in the town. Other families transferred to island municipality of Surigao Island it escape from the unforeseen calamity. Beside it happened also the unexpected pest resulted in the deaths of many carabaos and animals.

The sad malady decreased the income of the people and it was hard for them to pay their obligations to the government. The municipal government was not able anymore to sustain their expenditure, hence the retentions of the municipality to a barrio under the Municipality of Gigaquit. However Claver produced native executive namely. Hon. Doroteo Perlas and Hon. Pedro A. Paqueo, respectively. The Municipal Secretary was Mr. Florentino Avelino and the judges who were appointed in the succession were Judge Canuto Lantoria, a native of Claver and Judge Matias Galeon and Judge Maximo Samontina both Boholano immigrants respectively.

For fifty long years Claver was administered by Barrio Lietenants only. Some of them who run the barrio efficiently who were worthy to be remembered, were Ho.n Marcos Mira, Hon. Benito Paqueo, Hon. Francisco Gortea and Hon. Feliciano Larase.

In 1902, Hon. Pedro A. Paqueo of Claver in 1903 to 1905 was elected Mayor of Gigaquit. He tried his best t to work for the return of barrio Claver to a municipality. But the Colorum uprising in 1924 hindered his dreams and Claver remained a barrio.

However, during the intervening period before Claver returned to her former status as a municipality, there were several persons in Claver who were elected municipal positions in the municipality of Giigaquit. As Vice Mayors, there were three active persons who were elected. Hon. Francisco Verdun, Hon. Agapito Ocon, Hon. Gregorio Dedumo. For municipal councilors, they were, Hon. Faustino Saranza, Hon. Eugenio Galgo, Hon. Pedro Mira, Hon. Jose Ladaga, Hon. Jorge Aceron, Hon. MArcelino Navallo, Hon. Tranquilino Latorre, and Hon. Floro Basul, respectively.

Time has come that economy in Claver has rose up. The people were able to produce much rice and the coconut plantations of the people gave fruits in abundance. This made them money will do Taxes were paid frontally to the treasury of Gigaquit.

There were three reasons why Claver could not return hasten as a municipality. First, there were only very few people who possessed enough talent to run a municipal government. Second, Gigaquit wished Claver be under her verdantly as a barrio, because the Claver people were best tax payers. Third, municipal manipulations were under roundly sustained, so that political people of Gigaquit could always hold the reign of power notwithstanding the able minded people of Claver.
The situation has change. Several young blooded citizens of Claver came into being. The acquired already enough knowledge in politics. Gigaquit could no longer hold Claver as member of her political family. She recognized and acknowledge already the capacity of the young leaders of Claver to run their own government.

The Divine Providence has given the golden time and situation for Claver's emancipation. It was during that time that the Municipal Mayor and the three Municipal Councilors were from GIgaquit and the Municipal Vice Mayor and three Municipal Councilors from Claver. The administration was headed by Mayor Jun Gijal. The municipal officials of Gigaquit during that administration were very sympathetic to Claver's longing. So the municipal councils prepared a resolution requesting His excellency President Ramon Magsaysay, President of the Republic of the Philippines, to give Claver honorable status as a municipality in the province of Surigao del Norte.

On September 13, 1955 President Ramon Magsaysay signed the Executive Order No. 126 declaring Claver a municipality with Nuevo Campo Inferior, Panatao, Cabugo, Urbiztondo, Taganito, Daywan and Magallanes as barrios under the municipality of Claver. The inauguration of the new municipality would have been on January 1, 1956, but because of love for Independence of Claver, the municipal officials of Gigaquit together with the people of Claver, the inauguration was made earlier by Provincial Governor Hon. Fernando Silvosa. The inauguration took place on December 5, 1955. The following appointed officials were: Hon. Felicisimo E. Paqueo Municipal Mayor, Hon. Regulo D. Ravelo Municipal Vice Mayor, Hon. Enrique Manlimos, Hon. Trepodes G. Samontina and Nestor Verano Municipal Councilors.

2.4.5 Existing Social Infrastructure and Services

2.4.5.1 Power Supply

Electric power in Carrascal is served by SURSECO II whose source comes from the National Power Corporation based in Iligan City and distributed among 1,669 households. Of the 14 barangays in Carrascal only one (1) isolated barangay has no electricity. Although 13 barangays have access to electric power supply, only 60 percent of the total number of households has actually connected and the rest remained utilizing other forms of fuel for lighting. More than 89% of the total number of connections in Carrascal is of domestic use with an average assumption of 20 kilowatt hour per month while streetlights for public places consumed an average of 3,592 kilowatt hour per month.

In Claver, all barangays are energized, and the residents enjoy the 24-hour power service of SURNECO. Power interruptions however occurs due to maintenance works done regularly especially during calamities and bad weather conditions. About 3,150 households were being served by the local power franchise. The projected average power consumption of Claver is 2 Megawatts (MW) for industrial, 1 000 MW for commercial, 2.725 MW for public buildings and 4200 MW for streetlights, respectively.

2.4.5.2 Water Supply

In Carrascal, water supply Level I is available to 51.88% of households, Level II for 24.92% of total households while Level III is present for 7.22% of total households. Around 16% of households have partial access to water. Out of 51.88% households being served by Level I water supply, 18.03% have direct access to water by shallow wells and 1.74% have direct access to water by electric pumps.

In Claver, most of the water systems in 14 barangays are still on Levels I and II. The barangays served by Level 1 water system are Brgys. Wangke, Cabugo and Hayanggabon; Level II are Panatao, Urbiztondo, Taganito and Cagdianao. There are 225 households served in Panatao by the said water system, 85 households in Wangke, 365 households in Cabugo, 430 households in Urbiztondo, 550 households in Taganito, 354 households in Hayanggabon and 348 households in Cagdianao, respectively. The Poblacion barangays have level III water system but are not yet operational. The water source is located in Brgy. Daywan approximately 4 km from the town proper with a storage tank that can accommodate 150 meter3 capacity. Immediate budgetary allocation will be necessary to further expand its water distribution facilities that can serve residents as soon as its operation starts.

The total number of households covered by potable water supply in Claver is around 98% with a remaining 2% of the household utilizing doubtful source for drinking. On another note, there is no local waterworks system in the municipality at this point in time. However, there is one commercial water refilling/ (deep well facility) in the locality situated in Purok 5, Barangay Bagakay which has passed the bacteriological laboratory standards of the Department of Health.

The existing water supply in Claver is insufficient for domestic and commercial use when influx of population is taken into consideration. Hence, there is a pressing need to install the waterworks system in the locality to manage the water services.

2.4.5.3 Education

The elementary school facilities of Carrascal are composed of 15 elementary schools, 7 schools are complete elementary schools, 6 are complete primary schools and 2 are incomplete primary schools. It has 99 teaching and non-teaching personnel. Carrascal has three (3) existing National High Schools, the Carrascal National High School (CNHS) which is located at Nocot, Barangay Saca, Panikian National High School (PNHS) and the Adlay National High School. Presently, Carrascal National High School has the largest number of enrolment since it is considered as the center for secondary education in the municipality. Panikian National High School has 320 students for school year 2001-2002 while Adlay National High School has 187 enrolled students with seven (7) full time teachers. The teacher pupil ratio is one teacher for every 26 pupils and one classroom for every 32 pupils. The textbook-pupil ratio ranges from 1:3 to 1:4. Sacred Heart School of Arts and Technology Foundation, Inc. is a private school, which offers college courses for high school graduates of the municipality. The school is currently offering 12 courses and special courses for computer-related courses.

Claver, on the other hand, has two (2) educational levels available. All 14 barangays comprising the municipality has one elementary school. The Claver National High School is located in Brgy. Tayaga (Poblacion West) being served daily by a school bus has a satellite campus in Barangay Taganito now being separated as Taganito National High School caters the 4 mining communities of Brgy. Urbiztondo, Brgy. Taganito, Brgy. Hayanggabon and Brgy. Cagdianao. There are 5 elementary schools which are vulnerable to flooding particularly during the wet seasons from November to February. Worse scenarios which flooded the school site during monsoon season which can be aggravated by the climate change and typhoons which mostly hit in the area. There are 12 elementary and 2 primary schools wherein 11 schools are integrating pre-schools as part of their multi-grade system. There are 3,336 pupils enrolled in the primary and elementary level which slightly increased as compared to the previous school years. Based on CBMS Survey, there are 993 pupils who are not attending school. Claver Central Elementary School has the highest enrolment for this school year while Tayawod Primary School has the least school population.

2.4.5.4 Communication

In Carrascal, there is a telecommunication office to service the needs of the residents. Many residents of Claver have already acquired cellular and mobile phones and utilized the services offered by SMART® and GLOBE® telephone companies to compensate for the poor service of the telecommunication office. Mails and parcels are handled by the Postal Services Office manned by 2 personnel. The local post office is located at the municipal building. It has a money order machine and local mails are sent through the postal system. It has a mailing station outside the Poblacion for the convenience of the mailing public.

In Claver, there are no telephone company operating for individual subscribing but telephone booths for international and local connections are available. Most of the households owned cell phone units as main communication facility used because of its affordability. Existing cell sites powered by Smart, Globe and Sun Telecommunications are all operational located in Brgys. Taganito and Ladgaron, Bagakay. The accessibility and coverage of internet services is very limited even the offices of local government are not yet connected. With the present situation, inter-agency wireless transactions and communications are at low very low pace. Only few establishments have access to internet services through PhilCom, Smart and Globe broad bands. Postal services in Claver need additional manpower for the prompt delivery of correspondence and other important communications considering the present coverage and population. There are private couriers available in the area or under the service area which are mostly based in Surigao City as their main office.

2.4.5.5 Peace and Order (Protective Services)

Carrascal PNP Headquarters has a two (2) storey semi-permanent building located besides the municipal hall. Carrascal Police Station is located along Trugillo St. and has a total strength of twenty-six (26) PNP personnel composed of one (1) Officer with the rank of INSPECTOR and twenty-five (25) PNCOs with one policewoman detailed as Women's and Children's Desk (WCD) PNCO. The present police force is augmented by 185 Civilian Volunteer Organization (CVO) members/Tanods in all fourteen (14) Barangays and a CAFGU Detachment located at Barangay Panikian

The Municipality of Claver is one of implementing arms of local government in the attainment of its mission, vision and goal. Its functions are to protect the lives and properties of the community, maintain peace and order, ensure public safety and further strengthen the government capability to effectively deliver the basic services to the people towards the attainment of peaceful, self-reliant and progressive communities within a just social order. he construction of Claver Municipal Police Station started last March 1991 to effectively serve the needs of the people in the Maintenance of Peace and Order to ensure Public Safety and Security.

Claver Municipal Police Station is located at Brgy. Tayaga, Claver, Surigao del Norte. It has a total of 24 PNP personnel broken down into: 2 PCOs, 18 PNCO's and 4 NUP's. The police to population ratio is 1:1,184.

2.4.6 Public Health and Safety Profile

2.4.6.1 Public Health Services

In Carrascal, there are three (3) barangay health stations located in Adlay, Panikian and Babuyan representing primary level of health service manned by a midwife capable of providing health education, controlling locally endemic diseases, giving immunization, rendering MCH and family planning, advising on nutrition, treating communicable illnesses and supplying essential drugs. The main health center which is located in the Poblacion proper delivers same services with addition on doing minor surgeries and simple laboratory examinations. It has 5-bed infirmary which caters to serve the populace needing consultations off office hours and can admit manageable cases in this setting. This institution serves also as a venue for patients who are to be referred to bigger hospitals for further work up and management. Health services had long been devolved to respective LGU's however the Department of Health had been providing logistics supporting devolved public health programs especially those of national importance.

Claver has one (1) Rural Health Unit (RHU) located in the town proper approximately 300 m from the national highway which is open Monday through Friday from 8:00 A.M. to 5:00 P.M. to cater basic healthcare services to its constituents. A birthing facility is also located adjacent to the RHU which operates 24 hours providing maternal and newborn services such as normal delivery, newborn care and postpartum care. Routine health services being offered in the RHU include prenatal and post-natal check-up, family planning methods, pre-marriage counselling, immunization, consultation, medico-legal examination, Tuberculosis directly Observed Treatment Short Course (TB-DOTS), sputum smearing, and basic laboratory services such as Complete Blood Count (CBC), Urinalysis (U/A), Stool Examination (SE), and Fasting Blood Sugar (FBS). Tooth Extraction is scheduled per visiting dentist's advice. The RHU has a counterpart satellite in the component barangays popularly known as the Barangay Health Station (BHS), which served as the pivot point in healthcare service delivery to the constituents. Various health program implementations take place in the BHS including immunization, consultation, prenatal and postnatal check-up and feeding programs.

2.4.6.2 Morbidity and Mortality

In Carrascal, there are a total of 2,865 general consultations conducted by the Rural Health Unit and this constituted a total GMCR of 215 per 1,000 population. Currently, there are 132 hospitalizations in Carrascal and hospitalization rate is 10 hospitalizations per 1000 population which is only 4% of the total GMC conducted.

There are 68 number of deaths registered in the area and 50 of the death occurrences ages more than 50 years old and the current proportional mortality ratio of those death 50 years and above is more than 73%. The PMR of 50 years and over is quite high compared to the developed countries. On the other hand, the current crude death rate of Carrascal is 5 per 1,000 population. There are 7 deaths occurrence for infants' ages less than 1 making the infant mortality rate of 5 against the 270 live births. At least only 1 death occurrence for young child ages 1-4 years old and no maternal death being experiences for the current year.

It is interesting to note that the ten leading causes of morbidity in years 1997- 2001 is still predominantly due to communicable cases like pneumonia, bronchitis and colds (no pneumonia) which are all respiratory tract diseases. Wounds, asthma, URTI, anemia, UTI, abscesses (skin infections) complete the list (Error! Reference source not found.**2.4.9**).

The leading causes of mortality among the population in 2001 on the other hand is not anymore due to communicable diseases which predominate the previous years (**2.4.10**) but due to lifestyle diseases manifested by hypertensive cardio vascular disease, cancer and coronary artery disease. Pneumonia even is at the bottom while nobody died from PTB surprisingly.
The trend now is shifting from communicable to non-communicable diseases.

Table 2.4.9: Leading Causes of Morbidity

1997		1998		1999		2000		2001	
Cause	**No.**	**Cause**	**No.**	**Cause**	**No.**	**Cause**	**No.**	**Cause**	**No.**
No Pneumonia	750	No Pneumonia	327	Pneumonia	476	Pneumonia	400	Pneumonia	311
Pneumonia	745	Pneumonia	282	No Pneumonia	273	No Pneumonia	385	Bronchitis	267
Bronchitis	318	Bronchitis	221	Bronchitis	213	Bronchitis	199	No Pneumonia	237
Anemia	250	Influenza	183	URTI	164	URTI	165	Wounds	150
Influenza	217	Anemia	120	UTI	126	Anemia	150	Asthma	145
UTI	186	UTI	102	Skin disorder	102	Skin disorder	124	URTI	144
Parasitism	185	Parasitism	101	Anemia	124	Influenza	94	Anemia	121
Skin disorder	125	Wounds	98	Wounds	96	UTI	93	UTI	106
Hypertension	95	Asthma	83	Asthma	81	Asthma	85	Abscess	96
Wounds	85	Abscess	79	Influenza	76	Wounds	80	Impetigo	81

Table 2.4.10: Leading Causes of Mortality

1997		1998		1999		2000		2001	
Cause	**No.**	**Cause**	**No.**	**Cause**	**No.**	**Cause**	**No.**	**Cause**	**No.**
PTB	8	Pneumonia	1	Pneumonia	15	HCVD	13	HCVD	10
CVA hemorrhage	6	Cancer	1	CVA	9	Cancer	8	Cancer	8
Pneumonia	6	Drowning	5	Sepsis	9	Accidents	6	COPD	7
Anemia	5	Anemia	4	Cancer	8	CAD	5	CAD	5
Septicemia	4	Acute ML	3	CAD	7	Pneumonia	5	Asthmatic	3
Severe disease	3	CVA Sepsis	3	COPD	6	Peptic ulcer	5	Diabetes	3
CHF	2	Sepsis	3	Accidents	4	COPD	4	Prematurity	3
Meningitis	2	PTB	3	Asthmaticus	4	PTB	4	Anemia	3
Accident	1	Peptic ulcer	2	PTB	3	Anemia	2	Bleeding pur	3
Asthmaticus	1	Asthmaticus		Renal failure	3	Diabetes	2	Pneumonia	2

2.4.6.3 Environmental, Health and Sanitation Profile

In Carrascal, the usual manner of disposing waste is through burning followed by garbage collection. Other methods are composting and burying. Segregation of waste is also done in the municipality. Containers marked “malata” for biodegradable wastes and “di malata” for non-biodegradable wastes are positioned in deliberate places all over the town. Panikian High School with the support of the LGU put up a recycling center for those non-biodegradable wastes like plastic wrappers. Making of Compost Pits in every household is also encouraged by the LGU. The Carrascal National High School with the full participation of the students also created a composting area for combustible wastes. Carrascal has also its dumpsite strategically located 4km away from the town proper in Kayawyawan, Brgy. Bon-ot, Carrascal, Surigao del Sur. Collected garbage are not classified as hazardous.

Most of the people in Carrascal had been using water sealed toilet facility especially among the household in the poblacion area. However, there are still households that do not have toilet facilities like the far-flung barangays of Pantukan and Dahican. Though there is a decreasing incidence of diarrhea, the municipal government cannot afford to wait for an epidemic to arise. Toilet facilities need be installed in these barangays.

2.4.7 Socio-economic Profile

2.4.7.1 Local Economy

Carrascal has no existing major industry, since the Ventura Timber Corporation in Sitio Ban-Ban, Barangay Panikian, Carrascal, Surigao del Sur ceased to operate. In 2006 a mining company started operating in Barangay Adlay and this is the only industry in the municipality. Small industries such as rice mills, welding shop, bakery and other small businesses do exist in the Municipality. These are mostly sari-sari stores which provide many families with extra income. However, big purchases are done either in Surigao City or Tandag where big commercial establishments offer more extensive goods at lower prices.

Mining industry had since dominated the economy of Carrascal with three mining companies operating simultaneously and more are coming. Today it is the sole source of big income for the municipality considering the tax alone that these companies are paying. Jobs are created, and residents of host barangays are getting priority employment. This promotes liquid money circulation while driving the small-scale industries to flourish thereby creating more livelihoods and more income sources.

Claver is the province’s mining bed as evidenced by the presence of several mining industries. Presently, there are companies operating in the municipality particularly in barangays Taganito, Hayanggabon, Urbiztondo and Cagdianao. Along the HIPADA areas, Claver has the largest mining area in the province, followed by Surigao City and Taganaan. At present, Taganito Mining Corporation is the major industry player in the locality. With the establishment of Taganito High

Pressure Acid Leach (THPAL) Processing Plant of Nickel Asia Corporation, this is considerably the biggest nickel processing plant not only in the region but in the whole country. This project will operate in a 68-hectare lot in Brgy. Taganito being declared as Special Economic Zone. Taganito HPAL processing plant employed over 1,000 skilled and unskilled workers during its construction phase.

2.4.8 Public Access

Carrascal has a total road network of 64.17987 km. Out of this total, 38.40% is classified as national roads, 32.72% is provincial roads; 14.15% municipal urban roads and 14.73% as barangay roads. Only 12.09% of the total road length is paved and the rest remains unpaved or the gravel type but poorly maintained. "Habal-habal" motorcycles are the common main transport from inner barangays and farmlands to the poblacion. Motorized trisikads are plying the low elevated barangays via the secondary coastal road to the poblacion. Transport utilized by commuters going to Surigao City to the north or Tandag to the south are buses, PUJs and vans. Carrascal has a new terminal located along the highway, which serves buses, PUJs and vans plying the routes of Tandag and Surigao Cities. Commuters on the coastal barangays use fishing boats and pump boats in going to the poblacion, to nearby towns and to other barangays.

Claver has full access of roads to the neighboring localities. The road network system of is satisfactorily established. It has 32 km National Road which 93.75% of this are already concreted, 20.38 km Provincial Road with 7.75% concrete, 7.85 km Municipal Road with 59.62% concrete and 20.10 km Barangay Road with 14.36% concrete. However, the condition of national road is good, municipal and barangay roads are poor and the provincial roads are critical that needs immediate rehabilitation. Claver has several concrete bridges - Silopan and Daywan bridges in Brgy. Daywan, Pangi and Ladgaron bridges in Brgy. Ladgaron, Clarin wooden bridge in Brgy. Tayaga, Maibay bridge in Brgy. Sapa, Magallanes bridge in Brgy. Magallanes, Wangke bridge in Brgy. Wangke, Cabugo bridge in Brgy. Cabugo, Capandan bridge in Sitio Capandan, Urbiztondo, Taganito bridge in Brgy. Taganito, Hayanggabon bridges I and II in Brgy. Hayanggabon and Kinalablaban bridge in Brgy. Cagdianao. Daywan, Clarin and Maibay bridges are on critical conditions that need for major repair. Pangi, Ladgaron and Magallanes bridges are still good while Taganito bridge is in poor condition that needs monitoring and maintenance.

2.4.9 Perception Survey

Initial perception survey was also conducted for 354 households in Brgy. Adlay, 256 in Brgy. Pantukan and 248 in Brgy. Cagdianao. The respondents were randomly interviewed and surveyed. Questions in the survey covered the following:

- Gender
- Age
- Civil status
- Religious affiliation
- Educational attainment
- Occupation
- Place of work
- Number of years earning income
- Monthly income
- Length of stay in the area
- Intention to out-migrate
- Type of Toilet
- Source of Water
- Current Environmental Conditions
- Awareness on the Proposed Project
- Impacts of Proposed Project: Positive and Negative
- Perception and attitude towards the Project

2.4.9.1 Brgy. Adlay

Perception
Most of the respondents are not aware of the proposed project with 219 respondents or 62% while 135 respondents or 38% are aware.

Perceived positive effects from the project
Most of the respondents believed that the proposed project will generate employment for the local residents.

Opinions of the project
Most of the respondents stated that can greatly help in improving the community and local residents.

2.4.9.2 Brgy. Pantukan:

Perception
Most of the respondents are aware of the proposed project with 223 respondents or 87%. 26 of the respondents or 10% are not aware while 7 respondents or 3% have no answer.

Perceived positive effects from the project
Most of the respondents believed that the proposed project will generate employment for the local residents.

Opinions of the project
Most of the respondents stated that can greatly help in improving the community and local residents.

2.4.9.3 Brgy. Cagdianao

Perception
Most of the respondents are not aware of the proposed project with 169 respondents or 68%. 62 of the respondents or 25% are aware while 17 respondents or 7% have no answer.

Perceived positive effects from the project
Most of the respondents believed that the project will generate employment for the local residents.

Opinions of the project
Most of the respondents stated that can greatly help in improving the community and local residents.

2.4.10 Displacement of Settlers

There will be no displacement of settlers that will take place.

2.4.11 In-Migration

In-migration is likely to occur brought about by workers from the head office of 4DVDI coming in and out of Carrascal and Claver because of the project. Although the 4DVDI's hiring policy will give preference to qualified locals, in-migration may further be increased if there are no qualified applicants from the host barangays or municipalities. 4DVDI will encourage that migrant workers will participate in social activities and social development programs to interact with the community.

2.4.12 Cultural/Lifestyle Change

The cultural practices in Carrascal and Claver will not be affected by the project as these will continue to be celebrated and 4DVDI will support these celebrations. However, there will be change in lifestyle of the community, which will be for the better because the project will contribute to improvement of the people's standard of living. This will be brought about by additional stable jobs and higher household incomes. As a result, the affected families will be capable of giving their children proper education and widen their opportunities. 4DVDI shall encourage modest lifestyle and simple living standards in accordance with its philosophy. On the contrary, 4DVDI will encourage families to participate in livelihood projects that will be sponsored by the company.

2.4.13 Impacts on Physical/Cultural Resources

The project will not affect any physical nor cultural resource in Carrascal and Claver. It will even support and assist the customs and traditions of the community and assist in the improvement of the physical resources through its social development programs.

2.4.14 Threats to Delivery of Basic Services/Increase in Demand for Resources

The project will not pose threat to delivery of basic services because it will not compete with the services being provided by the local and national government.

Where skills are not available in the locality, the 4DVDI will bring in skilled personnel. A substantial number maybe required and these people are what this document refers to as transients. Although their residency is temporary, they nevertheless have needs similar to the permanent residents in the area. They will therefore compete for food, shelter, power, water and other resources that are available to the local community. Such additional needs will therefore exert pressure to the resources of the community.

4DVDI will provide some of the basic needs of the workers to make sure that they will not compete with the locals. Barracks will be constructed within the mining site to provide them with their housing needs and not compete for space with the local residents. Water will also be provided by 4DVDI. Services like medical, social, etc. will also be provided by 4DVDI to the workers and local residents. On food, the workers will buy their own possibly from local providers. Power can be provided by the 4DVDI through generators but the local electric cooperative assures the 4DVDI of power supply that will not interfere with that of the community's.

2.4.15 Threats to Public Health and Safety

If mitigation fails to reduce the adverse effects of mining to the community, then it will be the residents who will suffer in the end. This will be in the form of safety and health hazards. The community may be endangered by mudflows, flooding, and possibly slides particularly at the barangay proper if mitigating measures are not put in place. Dusts containing some amount of asbestos (chrysotile) fibers from serpentized peridotite may reach the community and possibly affect the health of residents in the area as well as the workers in the mine.

The mitigating measures presented in the preceding Land Module would be enough to ensure the safety of residents in the community and the miners. The asbestos content of the dust coming from the mining area will be studied with urgency. Nevertheless, measures like wetting the roads shall continue to prevent dust from being lifted regardless if they contain asbestos or not. Wearing of dust masks will also be required by company policy to further protect the workers from inhaling dusts that may or may not contain asbestos.

Occupational Health is among 4DVDI's priority as it is committed to implement structured approach to workplace health and safety in order to achieve a consistently high standard of safety performance.

4DVDI shall be responsible for the regular check-ups of workers and immediate treatment of any work-related sickness incurred by any worker. 4DVDI will cover employees and its dependents with an HMO plan. Moreover, the 4DVDI will have medical and dental missions and other health assistance projects for the community. Following are the responsibilities that 4DVDI is committed to:

- Ensure the health and safety of its workers and others in its workplace
- Ensure the health and safety of other persons is not put at risk from work carried out as part of its operations
- Provide and maintain a work environment that is without risks to health and safety
- Provide and maintain safe structures
- Provide and maintain safe systems of work
- Ensure the safe use, handling and storage of structures and substances

- Provide adequate facilities for the welfare of workers
- Provide information, training, instruction and supervision
- Monitor the health of workers and the conditions of our workplaces.

Workers must take reasonable care for their own health and safety while they are at work, and take reasonable care that their acts or omissions do not adversely affect the health and safety of other persons. They must comply, so far as they are reasonably able, with any reasonable instruction given by the Station Manager, as well as co-operating with any reasonable policy or procedure which relates to workplace health and safety. On a day to day basis, this includes:

- To the extent of the worker's control or influence over working conditions and methods, take reasonable care to work safely
- Making sure that the work area safe when leaving it
- Make proper use of all appropriate safeguards, safety devices and personal protective equipment
- Follow agreed safe working practices and rules
- Report all known hazards, accidents and incidents as soon as possible.

It is acknowledged that, in accordance with Labor laws, a worker may cease, or refuse to carry out work if they have a reasonable concern the work would expose the worker to a serious risk to their health or safety. The workers who cease work shall notify the relevant manager that they have ceased unsafe work as soon as practicable after doing so. Workers are also required to remain available to carry out 'suitable alternative work'. This would not however require workers to remain at any place that poses a serious risk to their health or safety.
Contractors, sub-contractors, and self-employed persons are required to:

- Comply with the contractual requirements with 4DVDI, laws, rules and regulations
- Have in place any work health and safety policies and programs required under safety legislation
- Consult with about safety matters and comply with policies
- Work safely and to include the safety of staff and visitors in their safety plans.

If any staff member believes that a contractor may be engaging in an unsafe work practice, they are required to report this issue to their manager.

Visitors and other persons' responsibilities are as follows:

- Take reasonable care for their own health and safety and for the health and safety of other persons
- Comply with, so far as they are reasonably able, all reasonable safety directions provided by 4DVDI
- Report all safety related incidents to 4DVDI
- Ensure the adequate supervision of any accompanying children
- Do not enter any restricted area without authorization or escort
- Do not bring or consume alcohol or illegal drugs at workplaces
- Do not willfully or recklessly interfere with property.

2.4.16 Generation of Local Benefits

The direct benefits resulting from the project include the creation of employment for both local and non-local manpower. Employment during the development and operations of the mine can create an improved economic condition where money circulation is loose and business opportunities are available.

4DVDI is committed to provide equal opportunities for employment of everyone, in compliance with the Labor Codes of the Philippines, Republic Act No. 10911 known as the Anti-Age Discrimination in Employment Act, and RA 7277 known as the Magna Carta for Disabled Person. 4DVDI will provide equal opportunities for employment of men and women, on the basis of their abilities, knowledge, skills and qualifications rather than on age or disability. The policy on hiring including the treatment of statutory benefits of the workers will be stipulated in the TORs and contracts with the local contractors to ensure compliance. To enhance the employment opportunities brought by the proposed project, 4DVDI will regularly coordinate with the host LGUs and barangays regarding the hiring of workers to ensure that the workers being considered are legitimate residents in the area. Moreover, by hiring local residents, some social conflicts associated with uncontrolled in-migration may be minimized. The respective contractor will be responsible to provide accommodation for their workers and equipped with the necessary social infrastructure such as potable drinking water, portable toilets, waste bins, first aid kits, etc. The temporary accommodation will also be provided with security guards for safety and security purpose.

One of the offshoots of the mining operation is downstream commerce. The project creates various opportunities for retailing, services, buy and sell, fishing, planting and others. The basic needs of the community will now grow and these needs must be met. This is where the law of supply and demand comes in. Enterprising residents of the barangays can therefore look at the actual needs of the workers and their dependents so that they can prepare what appropriate investment response will they adopt to earn them some income.

The operation of the proposed project is subject to excise tax wherein 2% of the gross income is allotted to the LGUs and divided into percentages for the Provincial Government, the Municipal Government, and the Barangay Government. The community is also entitled to additional social development benefits that are covered by 1% of the mining cost.

2.4.17 Traffic Congestion

The mining operation will have an impact in the traffic situation of the locality. Traffic density within the site may become high and the volume of cargo and delivery trucks that will be used for the delivery of construction materials and ores may contribute to traffic problem. With this, 4DVDI is committed to implement the Traffic Management Plan. The concept of the Traffic Management Plan is basically premised on the measures that will be implemented by the 4DVDI in coordination with and authorization of the LGU of Carracal and Claver. Nevertheless, during construction phase, the following mitigating and management measures will be implemented:

The provincial road is the main ingress/egress;
Proper scheduling of hauling of construction materials in relation to existing truck ban ordinances;
- No trucks and/or any kind of vehicles, i.e.: cars, motorcycles will be allowed to park outside the mill compound;
- Assign traffic marshals or officers to control the vehicular movements at the entrance / exit of the Project Site;
- Coordinate with the LGU of Carracal and Claver in crafting new and better routing scheme within the affected impact zone area;
- Posting of the project's own traffic officer to assist and coordinate with the LGU's Traffic Bureau for orderly flow of vehicle and pedestrian traffic within the identified route of trucks;
- Institution of mitigating and enhancement measures to avoid the risk of vehicular accidents (e.g. traffic accidents as a result of hauling of construction materials or construction spoils) and to promote safety like putting of safety and directional signages on the identified route of trucks;
- Assign sufficient number of owned traffic enforcers during rush hours;
- Comply with the DPWH load limit requirements of 13.5 MT/axle and the speed limit on roads ;
- Comply with existing road traffic and smoke belching laws, and;
- Conduct free trainings/seminars on Discipline and Traffic Rules and Regulations for all LGU traffic enforcer, Barangay officials and tanods as well as other interested motorists and pedestrians.

During project operation, the following mitigating and management measures will be implemented:

- The municipal road is the main ingress/egress;
- Proper scheduling of hauling of raw materials and finished products in relation to existing truck ban ordinances;

- No trucks and/or any kind of vehicles, i.e.: cars, motorcycles will be allowed to park outside the mill compound;
- Designate a substantial area inside the plant site for truck marshalling/holding;
- Address the parking demands/requirements of employees and visitors through proper allocation of parking slots;
- Assign a traffic marshals or officers to control the vehicular movements at the entrance / exit of the Project Site;
- Coordinate with the LGU in crafting new and better routing scheme within the affected impact zone area;
- Posting of the project's own traffic enforcers to assist and coordinate with the LGU's Traffic Bureau for orderly flow of vehicle and pedestrian traffic within the identified route of trucks;
- Post proper and permanent directional and safety traffic signs in coordination with Traffic Management Office of Carracal and Claver;
- Assign sufficient number of traffic enforcers during rush hours;
- Alert concerned government agencies regarding the upkeep and maintenance of the roads.
- Comply with DPWH load limit requirements of 13.5 metric tons/axle and the speed limit on roads;
- Comply with existing road traffic and smoke belching laws, and;
- Conduct free trainings/seminars on Discipline and Traffic Rules Education for all LGU traffic enforcer, Barangay Officials and tanods as well as other interested motorist and pedestrian.

3. ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) is formulated to minimize the potential adverse impacts while enhancing the beneficial effects of implementation of the project. This EMP shall serve as the environmental monitoring and implementing guidelines for the project.

With the identification of the key project activities at each phase and key impact thereof and the delineation of the important baseline conditions (Chapter 2), this Section summarizes the significant impacts and corresponding management plan/mitigating measures.

Table 3.1.1 provides the summary of EMP with performance rating or efficiency of measures. **Table 3.1.2** presents the detailed EMP.

Table 2.4.1: Summary of the Environmental Management Plan with Performance Rating

Potential Impact Per Project Activity Per Project Phase	Mitigating Measures	Rating/ Performance Of Mitigating Measures
A. Construction Phase		
A.1 Vegetation Clearing		
Reduction of vegetation, fauna disturbance and/or displacement	Replace trees cut as per DMO 05 of 2012 (which requires that for planted trees in private land and forest lands Species such as but not limited to narra, molave, banaba, mamalis, and bitaog (endemic) combined also with fruit bearing trees like jackfruit and guyabano shall be planted Establishment of bamboo plantation following the instruction of the DENR Secretary to establish Bamboo Plantation for the Mining Sector (contractors/ permittees/ permit holders) equivalent to 10% of the declared mined-out areas and 10% of the final mine area. Ensure the procurement of permit (tree cutting permit) from the DENR Office concerned	100% replacement of removed vegetation as per DMO No. 05 of 2012 and DENR Secretary's instruction for a Bamboo Plantation
Potential siltation of nearby bodies of water due to surface water run-off	Provision of temporary bunds around the stockpiles of overburden wastes and drainage systems to convey the storm run-off to siltation ponds. Zero discharge of silt ponds ponds prior to discharge to any body of water For each mining area to be opened, additional silt ponds will be established when necessary	100% conveyance of run-off water to siltation ponds
Generation of dust from site/access road preparation	Sprinkling of water at least once a day along the access road and project area during dry season.	100% compliance with RA 8749
A.2 Development of access roads, mining areas, and support facilities		
Degradation of surface water quality due to contamination from domestic wastewater	Proper maintenance and continuous operation of the 5 Hygienic Septic Tanks with regular desludging by third party contractor as needed, usually once every two years and 2 Waste Water Treatment Facility for domestic wastes and 6 settling ponds for run-off water	100% no discharge of untreated domestic wastewater to nearby bodies of water

Potential Impact Per Project Activity Per Project Phase	Mitigating Measures	Rating/ Performance Of Mitigating Measures
Siltation of surface waters	Continuous use of the six (6) settling ponds for our quarries, with total capacity of 1,300 m^3 as sediment barrier structure Provision of sediment barrier structure such as silt booms during port construction	100% compliance with RA 9275
Contamination of surface and ground water quality due to accidental oil spill	Continuous use of two (2) units existing oil-water separator sumps with total capacity of 90 m^3. Provision of oil residue recovery and reuse system Continuous implementation of existing oil spill contingency plan	100% compliance with RA 9275
B. Operational Phase		
B.1 Extraction and hauling of materials		
Siltation to streams due to erosion of exposed soil and Overburden materials	Progressive rehabilitation and revegetation of mined out quarries and planting barren lots to prevent soil erosion as per DMO 05 of 2-12 Utilize the recovered topsoil for re-soiling or as soil cover on waste dumps and other disturbed areas for rehabilitation and revegetation. All stockpiles shall be maintained and managed below the angle of repose of 45^0. Continue to implement sediment and erosion control plan Proper drainage design at the bench toes and access roads, to control the flow of runoff water, and divert it to series of 2 stage siltation ponds (5m. width x 10m. length x 5m. depth = 250 m^3) Rainwater and runoff collecting systems from crusher flatform shall be provided with primary and secondary silt traps	100% compliance to TSS standards
Generation of domestic wastewater that may contaminate the soil and receiving body of water	Proper maintenance and continuous operation of the 5 hygienic Septic Tanks with regular desludging by third party contractor as needed, usually once every two years and 2 Waste Water Treatment Facility for domestic wastes and 6 settling ponds for run-off water	100% conformance to DENR effluent standards (RA 9275)
Generation of solid wastes	Proper management of domestic solid i.e. provision of Material Recovery Facility for proper waste management (segregation, collection, minimization, reuse, recycle, treatment and disposal	100% compliance to RA9003
Generation of hazardous wastes from waste oil/ grease and spills from the heavy equipment and vehicles	Provision of 2,000 liter storage capacity for used oil provided with bund wall Regular (at least once a year) hauling of hazardous waste by DENR accredited transporter and treater	100% no oil spills and compliance to RA6969

Potential Impact Per Project Activity Per Project Phase	Mitigating Measures	Rating/ Performance Of Mitigating Measures
Generation of fugitive dust during the mining operations	Regular water spraying (minimum once a day, twice a day for hot weathers) of exposed dusty areas during high winds, and dry months. Establishment of a 20 – meter wide buffer zone planted with different species combination of shrubs, small and medium sized trees around the mine sites such as commercial hardwood tree species such as Gmelina and Santol as well as fruit-bearing trees/ herbs/ shrubs such as Papaya, Mango, Coconut, star apple and santol (endemic) and other endemic species such as but not limited to narra, molave, banaba, mamalis, and bitaog (endemic) as per DMO 05 od 2012.	100% no dust be seen in the area
Abandonment Phase		
Abandonment, decommissioning and rehabilitation		
Reforestation	Full implementation of FMRDP	100% compliance to Mining Forest Program and FMRDP
Land devaluation	Proper handling of excavated soil	100% compliance to RA 9003
	Full implementation of the FMR/DP	100% compliance to FMRDP

Table 2.4.2: Environment Management Plan

Project Phase/ Environmental Aspect	Environmental Component to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Indicative Cost (PhP)	Guarantees/ Financial Arrangement
Development and Operation	Land	Loss of vegetation	The 4DVDI will identify pristine forested areas of dipterocarp and diverse primary forest cover, as well as critical fauna, in order to delineate core zones that will to the farthest extent possible, be conserved for wildlife and fauna refuge. Progressive rehabilitation/revegetation shall be done immediately in mined-out areas. Donation of seedlings as replacement for cut trees will be initiated, supplemented by research and development for both flora and fauna biodiversity and the establishment of a seedling bank. Preparation and implementation of Biodiversity Management Plan incorporating the following: • Develop research programs in the mass propagation of Critically Endangered, Endangered, or Vulnerable species to ensure that hundreds of thousands of seedlings are available for transplanting back in rehabilitated, mined-out areas. The proponent may partner with a research institution or private company in the micropropagation of lady slipper and pitcher plants, these species being difficult to propagate using conventional methods. • Develop community-based approaches in the implementation of conservation and protection strategies to involve the host communities particularly IPs and make them realize that mining projects could be instruments of biodiversity gain rather than biodiversity loss.		3,000,000	EIS, ECC, EGF, MMT
Operation	Land	Loss of subsoil	Unavoidable and permanent since soil will be shipped out as ore. For stored top soil, keep secured from erosion.			EIS, ECC, EPEP, MMT monitoring
Operation	Land	Accelerated and excessive erosion	Cover the mined out area with plant remains or mulches. Reduce angle of repose of stockpiles, protect base of stockpiles, reduce slopes of cutslopes, bench the extracted areas, distribute surface runoff, compact loosen soil, etc.		8,000,000	EIS, ECC, EPEP, MMT monitoring
Development and Operation	Land	Habitat loss and displacement of wildlife	Preparation and implementation of Biodiversity Management Plan. Allow gradual displacement by slowing down operation in fauna populated areas. Rehabilitation of mined-out areas to reconstruct destroyed habitats.			EIS, ECC, EGF, MMT
Development and Operation	Land	Generation of mining waste	Unavoidable but soil will be used eventually for rehabilitation. Proper stockpiling of top soil and plant remains.		Part of mining cost	EIS, ECC, EPEP, MMT monitoring
Development and Operation	Land	Solid and hazardous waste generation	Implement 3Rs for domestic wastes at source level and establish a Material Recovery Facility. Provide separate storage area for hazardous waste and send these to DENR-accredited waste treater for treatment and final disposal.		100,000	EIS, ECC, EPEP, MMT monitoring
Operation	Land	Occurrence of mass-wasting processes	To avoid occurrences of mass wasting, there should be no steep slopes in stockpiles or cutslopes, no dumping of soil in gullies, benching of working areas is a must, compaction of filled areas, and stockpiling of loose materials.		Part of mining cost	EIS, ECC, EPEP, EGF, MMT

Project Phase/ Environmental Aspect	Environmental Component to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Indicative Cost (PhP)	Guarantees/ Financial Arrangement
Operation	Water	Siltation of streambeds and coastal areas	Construction of a Siltation Control System to include series of sabo dams, contour holding ponds, perimeter canals, siltation ponds with flocculation cell.		12,000,000	EIS, ECC, EGF, MMT
Operation	Water	Extreme discoloration of river and coastal waters	Monitoring of siltation in seawater in the form of total suspended solids and turbidity measurements will be conducted on a bi-annual frequency particularly in the inner bay and in stations where corals occur. Examination of sediment intrusion in coral colonies will be undertaken and comparatively assessed against baseline parameters on the degree of dead corals with algae (DCA) in the same stations assessed during baseline assessment. Surveys on diversity and abundance of macro-invertebrates of significant economic value to the local community will be conducted bi-annually in popular gleaning areas and stations assessed during the baseline survey. Moreover, the Project, in cooperation with local fishery scientists will identify and delineate areas of bivalve and crustacean spawning habitats (e.g. river estuaries) so that such areas can be monitored for abundance and recruitment of macro-invertebrates.			EIS, ECC, EGF, MMT
Operation	Water	Deterioration of water quality				EIS, ECC, EGF, MMT
Operation	Water	Loss of groundwater recharge areas	Implement progressive rehabilitation in mined-out areas to recover recharge zones. Limit disturbance of vegetation to the delineated extraction areas. Avoid unnecessary destruction of other areas.		Part of the rehabilitation cost	EIS, ECC, EGF, MMT
Operation	Water	Damage to some marine ecosystems	Same Siltation Control System with perimeter canals and flocculation process.		Part of the cost of siltation and discoloration control system	EIS, ECC, EGF, EMB, MGB, MMT
Operation	Water	Modification of freshwater habitat	Erosion must be effectively controlled at source. If there are residuals, siltation control system must be implemented as recommended earlier. Discoloration must be checked using flocculants.			EIS, ECC, EGF, MMT
Operation	Air	Dust generation	Frequent wetting of hauling roads to prevent lifting of dust. Use of uniformly graded base course in road surfacing to suppress dust generation. Workers must use dust mask always to prevent inhalation.		2,000,000	EIS, ECC, EGF, MMT
Operation	Air	Increased amount of NOx and SOx	Engines should always be kept in tip-top conditions. If available, use of catalytic converter is encouraged.		Part of maintenance cost	EIS, ECC
Operation	Air	Noise generation	Engines shall be equipped with appropriate mufflers.		Part of acquisition cost	EIS, ECC
Operation	People	Resource competition	4DVDI to provide barracks for its workers, a water supply system for the community and minesite, medical services, and others.		Part of development cost	EIS, ECC
Operation	People	Increased in safety and health risks	Mitigating measures cited in the land module for mass wasting and air module for dust generation also apply to this module. IEC on these risks shall also be initiated by the 4DVDI.		200,000 for IEC	EIS, ECC

Project Phase/ Environmental Aspect	Environmental Component to be Affected	Potential Impact	Options for Prevention or Mitigation or Enhancement	Responsible Entity	Indicative Cost (PhP)	Guarantees/ Financial Arrangement
Operation	People	Non-assimilation of diverse culture	Initiate social gathering to promote interactions that would lead to harmonious relationships among peoples of different regions.		Part of SDMP cost	EIS, ECC
Operation	People	Proliferation of vices	The company should encourage prayer meetings and sports development and competitions to divert attention of workers from the places of vices.			EIS, ECC

4. ENVIRONMENTAL RISK ASSESSMENT

4DVDI has high regard to the environment, health, and safety and is committed to serve its consumers' and stakeholders' social and economic needs by providing livelihood projects, technical trainings and career opportunities to deserving local residents of Barangays Pantukan and Adlay in Carrascal, Surigao del Sur and Barangay Cagdianao in Claver, Surigao del Norte.

Human safety is the major concern of the Environmental Risk Assessment (ERA) in the context of the PEISS. DAO 2003-30 defined ERA as a process of analyzing and describing the risks associated with a project activity to ecosystems, human health and welfare. Annex 2-7e of the RPM provides the guidelines on the degree of ERA requirements and preparation as provided below:

Level 1: Preparation of an Emergency/Contingency Plan
Level 2: Preparation of an Emergency/Contingency Plan and ERA Report

4.1 HAZARD ANALYSIS

There are two (2) types of major hazards identified within the project site and vicinity, natural hazards and safety hazards. Natural hazards include earthquake, tsunamis, liquefaction, mass movements, typhoons, and storm surges. Safety hazards include fuel depot fire and explosions, sea craft movements and moving vehicles and equipment.

On natural hazards, earthquake can be generated by the Philippine Trench or by the Philippine Fault Zone both of which can produce high magnitude tremors. Tsunamis can be generated by Philippine Trench wherein the Philippine Sea Plate subducts under the Philippine Mobile Belt. Mass movements may occur in the mining area where disturbances are expected. Debris flow may also occur at the Marga River should its watershed suffers from multiple landslides and strong floods will deliver the slide materials to the Adlay community including the campsite. Typhoons may also hit the area even if it is not located along the typhoon belt. Two (2) super typhoons in recent history passed the eastern seaboard north and south of Surigao del Sur, thus, it is also possible that one may directly this province. Storm surge may also occur in the area during a passage of a super typhoon assuming the eye of the typhoon passes south of Carrascal.

Fire and explosion at the fuel depot could be risky to life and properties. Although diesel fuel can evaporate at 52°C and cannot spontaneously ignite at ambient temperature, sabotage could be a source of risk. The fuel tank will be constructed inside the campsite. Sea craft like LCTs consistently and bulk carriers can change position from the constant pounding of waves and thereby creation a condition susceptible to accidents. Collision or sea crafts and possibly oil spills are the hazards. Hauling of ore and back constantly keeps the trucks on the move, sometimes at faster speed allowed by regulations. In case accidents happen in the mountains where steep road gradients has to be traversed. It could also happen in the lowlands and may involve people being victims of accidents. **Table 4.1.1** presents the lists of the hazards and the risks associated with them.

Table 4.1.1: Hazards and Associated Risks

Hazard	Risks	Location
Natural Hazards		
Earthquake	Damage to properties, injuries or even death to workers	Minesite, campsite, hauling roads, causeway
Tsunami	Destruction of Causeway, inundation of communities, damage to properties, livestock and farms, livelihood, injuries to persons and deaths	Causeway, Adlay coastal communities
Liquefaction	Damage to structures	Campsite and causeway
Mass Movements	Settlement in Causeway, Landslide in the minesite and mountain hauling roads	Causeway, Mountain hauling roads
Typhoons	Damage to properties, injuries or even deaths to persons, loss of livelihoods from strong winds and floods	Causewway, minesite, and campsite

Hazard	Risks	Location
Storm Surge	Destruction of Causeway, inundation of communities, damage to properties, livestock and farms, livelihood, injuries to persons and deaths	Causeway, Adlay coastal communities
Physical Hazards		
Fuel Depot Sabotage	Fire and explosions may result to injuries, deaths and loss of property. Spills may create environmental problems.	Campsite
Moving Sea crafts	Collisions that may damage properties, injure personnel or cause their death. Spills may occur and destroy marine life.	Causeway and Carrascal Bay
Moving Vehicles and Heavy Equipment	Accidents with pedestrians, other moving vehicles or even stationary properties may cause injuries, deaths and destroy properties.	Minesite, hauling roads, causeway, campsite, highway, communities

4.2 CONSEQUENCE ANALYSIS

The natural hazards could have wide-ranging consequences not only to the project site but to the community as well. For instance, an earthquake in its initial shaking can already create damage to properties and injures people. The succeeding shaking if large, can cause death and totally damage houses. The aftermath will even be lethal if tsunami and liquefaction occur. Earthquakes with epicenter offshore, strong enough and displacement of fault or trench is vertical, then tsunami can be generated. The waves produced can already create disaster and ensuing inundation can further aggravate things. Liquefaction if initiated can topple buildings and even houses but in the area this may cause minimal effects since tall buildings do not exist. Typhoons and storm surges are normally in associations. Typhoons can bring in heavy abnormal floods in fluvial and sweep the coasts with strong and high storm surges that can inundate the coastal areas. The crucial factor to watch aside from the intensity of wind and the tapering shape of a bay is the entry of typhoon, if located south of Carrascal, storm surge can be generated if in the north, no significant storm surge. This is because the direction of wind is anti-cyclonic and therefore when approaching the southern section of the town, will push the waves towards the shore.

Under ambient temperature, stored diesel cannot explode nor catch fire. Only when its flash point of 52oC will it emit flammable vapors and in such state can be ignited from an outside spark. Based on the MSDS of diesel, the substance cannot readily explode on its own but could be exploded by a bomb from a terrorist attack. This is remote however since the area is a peaceful place but outlaws exist somewhere nearby. The storage facility may be punctured from wear and tear or heavily or may crack if slammed with sharp hard object or tilt or topple from a strong earthquake. If any of these happens, a spill can occur and that is where the consequence comes in. This is a remote scenario, however, can happen given a weak structure to hold the diesel fuel in place. In the other safety issues, controls is the implementation of the safeguards which are normally incorporated in the safety standards of the company. For both, the consequence is accident and the risk may range from damage to property, injury and death. May even generate environmental disaster when large oil spill occurs.

4.3 RISK ANALYSIS

In all of the hazards and associated risk, the severity will be gauged according to the likelihood of occurrence and the consequence. In the matrix below, the risks are rated this way by assigning numbers to each risk and in **Error! Reference source not found.** the actual ratings of the hazards i dentified in the area are presented.

CONSEQUENCE
How severe could the outcomes be if the risk event occurred?

LIKELIHOOD
What's the chance the of the risk occurring?

	INSIGNIFICANT 1	MINOR 2	SIGNIFICANT 3	MAJOR 4	SEVERE 5
ALMOST CERTAIN 5	MEDIUM 5	HIGH 10	VERY HIGH 15	EXTREME 20	EXTREME 25
LIKELY 4	MEDIUM 4	MEDIUM 8	HIGH 12	VERY HIGH 16	EXTREME 20
MODERATE 3	LOW 3	MEDIUM 6	MEDIUM 9	HIGH 12	VERY HIGH 15
UNLIKELY 2	VERY LOW 2	LOW 4	MEDIUM 6	MEDIUM 8	HIGH 10
RARE 1	VERY LOW 1	VERY LOW 2	LOW 3	MEDIUM 4	MEDIUM 5

Figure 4.3.1: Risk matrix

Table 4.3.1: Perceived risk ratings of hazards present in the project area

Hazard	Risks	Rating
Natural Hazards		
Earthquake	Damage to properties, injuries or even death to workers	16
Tsunami	Destruction of Causeway, inundation of communities, damage to properties, livestock and farms, livelihood, injuries to persons and deaths	20
Liquefaction	Damage to structures	9
Mass movements	Settlement in Causeway, Landslide in the minesite and mountain hauling roads	9
Typhoons	Damage to properties, injuries or even deaths to persons, loss of livelihoods from strong winds and floods	15
Storm Surge	Destruction of Causeway, inundation of communities, damage to properties, livestock and farms, livelihood, injuries to persons and deaths	16
Physical Hazards		
Fuel depot	Possible fire, explosion and spills can produce injuries, death, damage to properties and environmental disaster (oil spill)	12
Moving seacrafts	Collisions that may damage properties, injure personnel or cause their death	9
Moving vehicles and heavy Equipment	Accidents with pedestrians, other moving vehicles or even stationary properties	12

4.4 EMERGENCY PREPARENESS AND RESPONSE PLAN

4.4.1 Introduction

An Emergency Situation is defined as any situation or occurrence of serious nature which may develop suddenly and unexpectedly, posing threat to life, property or even the environment that demand immediate action, including, but not limited to accidents, fire, explosions, acts of terrorism and sabotage.

The EPRP is a consolidated compendium of guidance for management of emergencies in all phases of the project cycle starting from the construction stage to the abandonment phase. This plan reflects the Management System that is applied to ensure compliance with 4DVDI's standards and other applicable Philippine legal requirements pertaining to rolling mill operations.

The scope of this EPRP is to set the minimum standards required and identifies the persons responsible for applying safe working conditions, procedures and practices including emergency situations potentially arising from plant operations. Whether natural or man-made the accidents or consequences of hazards will not be societal in scope but most confined to the plant personnel.

The success of this plan depends upon the cooperation of everybody at the site of an emergency and adherence to safety precautions and directives of this plan. The prime concern is everybody's safety which requires unwavering discipline and preparedness.

Notwithstanding that there are preventive measures to be undertaken, e.g. in the design and construction of major equipment, in the storage of diesel oil, it is prudent for operating companies to develop their internal response plans. The response and procedure will depend on the nature of the emergency and will include the following generic guidelines:

- Establishment of official detailed responses per type of emergency;
- Thus each plan would be relevant to emergency situations such as fire, earthquake, and even from attacks of criminal elements.
- Contact of necessary and important agencies and offices outside of the plant and facility for assistance depending on the type of emergency;
- Sought after or obtaining the assistance of the Disaster Reduction and Management Coordinating Council;
- Conduct of emergency drills with emergency evacuation as an integral part of the drill;
- Installation or securing of necessary emergency response facilities/equipment, e.g. firefighting system, oil spill containment, vehicles for use in emergency cases, situations and disasters; and
- Setting up of communication lines, e.g. with barangay, fire department, police department, clinics or hospitals.

During Actual Emergencies

- Designation of on-site emergency marshal;

  The on-site team leader should be pre-determined. Night shift supervisors are the logical leaders during night time emergencies.

  In case of more serious situations, the on-site team leader may have to call assistance from his supervisor who may be outside the plant premises.

- Communicating with outside parties for help when necessary:

  Contact numbers and means of communications should be well-established and be posted in conspicuous places in the plant premises and buildings.

- Execution of emergency procedure; and

  As a basic first step, emergency alarm signals shall be set on. The alarms may be coded depending on the type and seriousness of an emergency.

- Evacuation of personnel: Evacuation routes shall be well defined and known to the plant personnel.

After Emergency

- Audit or investigation of cause of emergency, if man-made such as fire
- Assistance to injured people

4.4.2 Purpose

The EPRP will serve the following general and important purposes:

- Guide and assist the proponent including all its employees, construction contractors' management, and other service provider/suppliers to handle emergency situation;
- Pre-identify responsible parties including their roles and responsibilities in handling emergency situations and cases;
- Achieve Zero Loss Time Injury, Occupational Illness and minimize the rate of incidents

- Comply with the Philippine legal requirement and international standards for handling emergency, health and safety practices and measures; and
- In case of emergency situations/cases and abnormal conditions, prevent contamination to groundwater, surface ground stability, destruction of flora and fauna and if they occur take measures to manage them in timely, safely and environmental friendly manner.

4.4.3 Emergency Action Team

The Emergency Action Team (EAT) shall be responsible for execution of the ERP. The Team is composed of:

- Chief Marshall – Construction/Project Manager,
- Members – LGUs including the Police Department, Fire Department, National Risk Reduction Committee members and the Health Department..

4.4.3.1 During the Construction Work

Under the general supervision of the Plant Manager, the EAT will be responsible for providing direction, guidance, and taking appropriate measures in safeguarding life and property. The EAT will also maintain close liaison with the 4DVDII and the affected communities/people.

4.4.3.2 During the Operations Phase

For serious accidents or emergencies the EAT shall be headed by the most senior personnel of the 4DVDI who would be at the site of the emergency.

4.4.4 Emergency Action Officer

Emergency Response Procedures shall be under constant close supervision of the Emergency Action Officer (EAO). The EAO shall maintain central control of the execution of the plans. All incidents under emergency situations shall be reported to him. The EAO shall command, coordinate, communicate and direct necessary actions and measures. The mandate of EAO is to establish command and control. However, this does not preclude abstinence of others, especially supervisory employees, from emergency tasks requirements. In addition to the emergency duties, the EAT shall provide training and/or arrange drills around the year so as to train employees on handling emergency situations.

4.4.5 Threat/Emergency Analysis

When there is an emergency incident e.g. fire or any type of threat or emergency as mentioned below, the first person who sees, hears or recognizes danger should immediately inform the EAO.

4.4.6 Designation of Safe Haven

Safe Haven is a place of safety, shelter, refuge or rest where there is no danger to life. Based on the type of incident, the safe haven shall be determined and designated where the people affected by an emergency situation shall proceed. In case of fire or explosion, the Safe Haven shall be the open space distant from the fire site.

By nature of the project the site is an open area; the safe haven should be pre-identified and well informed to all the personnel.

4.4.7 Evacuation Policy

In the event of any emergency, an alarm or siren or alternately a sound generating devise shall be blown/activated. The alarm may be coded to signify the intensity and nature of the emergency situation. The EAO shall direct and provide guidance to all persons affected. All affected persons shall be enjoined to strictly follow as instructed. The evacuation route/roads will be clearly delineated.

4.4.8 Standard Operating Procedures

4.4.8.1 Fire

All persons near the fire site shall be evacuated. Firefighting shall be handled by the EAO in the beginning until assistance from the LGU shall have been obtained.

4.4.8.2 Acts of Sabotage

Act of sabotage may cause fire, explosion, or damage to life and property. If a threat of sabotage is identified, the EAT shall analyze and assess the impact of such sabotage and will determine course(s) of action. The EAO shall maintain liaison with the concerned government agency (ies) e.g. Bureau of Fire Protection, Police Department, etc. Should a fire or explosion happen due to sabotage, the corresponding procedure specific to the situation shall be followed.

4.4.8.3 Terrorist Attacks or Kidnappings

The EAT shall analyze, assess and maintain constant but safe contact with the attackers, review all incoming and outgoing communications, designate or task others for action. The EAO shall ensure compliance of the planned strategy and psychological tactics to counter terrorism and provide guidance for dealing with these incidents. An officer shall be designated to maintain direct or indirect contact with the kidnappers, maintain liaison with the Client and other pertinent government agencies, principally the police or the military.

4.4.8.4 Natural Disasters

Natural disasters such as landslides and earthquakes are beyond human control with respect to occurrences. The EAT shall analyze the situation and take appropriate measures. In the event of earthquake, construction workers shall come out of their workplaces, wear hard hats, and assemble at Safe Haven. Search and Rescue Team shall start search and rescue operations when needed.

As a matter of complete guidelines natural disasters are included although the occurrence of such are deemed remote.

4.4.8.5 Severe Weather Disturbances

Extreme rainfall and strong typhoon events shall be prepared for. The most effective measure is precautionary action. Constant communications with the PAGASA and 4DVDI shall be made. Warnings which are posted at the websites shall be constantly referred to. Work stoppage may be mandated by management when severe weather disturbances may be forthcoming. The movements of vehicles shall be regulated on account of dangers slippery roads.

4.4.8.6 Search and Rescue Team

This team shall work in close cooperation with the LGUs. The primary function of this team is to handle the smooth evacuation of personnel, supplies and personal belongings during the emergency. It is also the duty of this team to rescue personnel trapped or injured in any of the rooms of the building.

4.4.8.7 Coordination and Communication

One of the most important aspects in any EPRP is efficiency of immediate communications with the parties which will manage an emergency situation. In an event of fire, explosion or an act of terrorism and sabotage, the EAO shall maintain constant coordination and communication with other senior officers at site or the department heads to locate employees trapped in a work area and take appropriate measures to evacuate them.

4.4.8.8 Transportation

The EAO shall plan ground transportation of personnel or evacuees for transport to the city, hospital, medical professionals, etc.

4.4.8.9 Funds and Expenditures

Under the direct supervision of the Project Manager, the EAO shall manage funds for meeting emergency expenditures. This includes, but is not limited to, transportation, medication, expenditures arising out of emergency treatment, hospital and medical expenses, etc. During the operations phase, 4DVDI shall ensure that the emergency response plans are properly supported by funds and resources, the latter involving people and equipment.

4.4.8.10 Emergency Numbers/Contact Persons

The emergency numbers/contact persons shall be posted in conspicuous places especially in the construction work temporary offices and in the toll booths, the latter during the operations phase.

4.4.8.11 Emergency Drills

A protocol will be developed for the conduct of emergency drills at regular schedules. Administration of first aid especially involving vehicular accidents is among the important drills/training that will be imparted to the EAO for the operations phase.

4.4.8.12 Trainings and Seminars

4DVDI shall organize and conduct regular trainings and seminars to be conducted by professionals in safety and emergency management. Attendance to these on the part of the personnel shall be compulsory. Members of the LGUs as well as heads of community sectors/sitios/tribes shall be invited as well for their own education.

Among the topics to be discussed during these training programmes are: proper use of PPE, First Aid, Basic Life Support such as Cardiopulmonary Resuscitation; training in the handling of injured persons; training in search and rescue operation and fire-fighting. The assistance of NDRRMC at least from the city level in conducting drills or training for earthquake situations should be explored.

4.4.9 Institutional Set Up

The Plant Team will constitute themselves as the Emergency Response Team. In as much as by its nature the occurrences of emergency situation cannot be reasonably anticipated the most senior personnel at the scene of an emergency situation will be designated as On Site Emergency Marshall. The supporting personnel will be dependent on the nature/extent of the emergency and the number of persons who may be exposed.

5. SOCIAL DEVELOPMENT PLAN/FRAMEWORK AND IEC FRAMEWORK

5.1 SOCIAL DEVELOPMENT PLAN

4DVDI shall assist in the development of the host communities in accordance with its Social Development and Management Program (SDMP) to promote the general welfare of the inhabitants living therein, will develop a program for the advancement of mining technology and geosciences to build up resources and mineral discoveries, improve operational efficiency and resource recovery, and enhance environmental protection and mine safety and intend to develop and institutionalize an Information, Education and Communication (IEC) Program for greater public awareness and understanding of responsible mining geosciences.

The results of the gathered data and information described the overall situation of the communities highlighting the distinguished and prevailing problems, issues and concerns currently present therein.

The objectives of the SDMP are:

- To deal successfully with the above-mentioned problems, a decision-making tool is designed to evaluate and assess internal (strength and weaknesses) and external (opportunities and threats) factors that contributes either to the progressive and sluggish development of a community.
- To make these programs/projects/activities (PPA's) capable of implementing, the company shall allocate 1.5% of the Operating Costs. Operating costs shall mean the specific costs of producing a saleable product on a commercial scale incurred in the calculation of the net income before tax. This shall include all costs and expenditures related to mining/extraction and treatment processing (inclusive of depreciation, depletion and amortization), excise tax, royalties, transport and marketing, and annual progressive/environmental management.
- To assist these communities in responding to their development needs, programs/projects/activities indicated in this SDMP are expected to achieve the following general objectives in the next five years:
- To increase the level of public awareness and knowledge on the impacts and benefits that the mining industry provides through institutionalization of Information, Communication and Education (ICE) interventions.
- To undertake research for the development of mining technology and geosciences and facilitate participatory development planning for the host communities.
- To assist in the development of the host communities through implementation of different components that will focus on human resource development and institutional building, enterprise development and networking, assistance to infrastructure development, access to education and educational support programs, access to health services and facilities and protection and respect to socio-cultural values.

Table 5.1.1: Social Development Plan/Framework

	Location	**Stakeholders Involved**	**Specific Activity**	**Estimated P/P/A Cost (in Php) per annum**	**Time-frame**	**Expected Results/ Outcome of the P/P/A**	**Remarks**
COMMUNITY DEVELOPMENT (75% OF THE 1.5% OF THE OPERATING COST) (P33,700,000.00)							
Human resource Development & Institutional Building	Within Impact Barangays	Inhabitants of the host Barangays	1.Trainings 2.Seminar 3.OJT/immersion allowances	4,000,000	5 years	Empowered individual	
Enterprise Development	Within Impact Barangays	Local Populace Members of Cooperative of affected landowners	• Establishment of Livelihood Projects • Support to Local Cooperative for access to low interest loan by members	3,000,000 2,000,000	5 years	Create sustainable livelihood	Apply the bottom-up planning and decision-making
Assistance to Infrastructure development & support services	Within Impact Barangays and Neighboring Communities	Local Inhabitants (not employed by the company)	• Assist the LGU in the construction of barangay infrastructures • Assist the LGU in maintenance of barangay public infra. • Support water system development	6,000,000 3,500,000 4,000,000	5 years	Be able to assist the LGU in maintaining public infrastructure within the host	
Educational Support programs	The Direct Impact Barangays	Local Inhabitants (not employed by the company)	• Support the barangay schools • Support to TESDA • Scholars/Scholarship for TESDA • Support to Day Care and Primary School	2,500,000	5 years	Better school service by the public schools.	
Access to health services	Direct Impact Barangays	Local Inhabitants (not employed by the company)	Medical service Feeding program	3,000,000 1,000,000	5 years	Assist the locals in terms of their health needs	
Others			Contingency	700,000		Activities not captured in the above activities	
				34,700,000			
IEC (15 % OF THE 1.5% OF THE OPERATING COST) (P7,00,000.00)							
Publication	Within R-13	Newspaper outlet	Newspaper, Journal, Souvenir Program, Local Tabloid, School Organ and other similar publication either locally and/or Regional.	3,000,000.00	5 years	Publication in local newspaper in coordination with PSEM	
Radio program	Within R-13	Radio stations	Any radio program that will about mining	1,500,000.00	5 years		

	Location	Stakeholders Involved	Specific Activity	Estimated P/P/A Cost (in Php) per annum	Time-frame	Expected Results/ Outcome of the P/P/A	Remarks
Support the IEC of the Mining Industry in R13	Within R-13	Mining industry group	Support the mining industry's initiative in R-13.	2,000,000.00	5 years	Better understanding bout benefits of mining by students	
Contingency			Others	500,000.00			
DMTG (10% OF THE 1.5% OF THE OPERATING COST) (P4,500,000.00)							
Support the technical upliftment of Mining Engineers	Within R-13	Professional engineers	Support the PSEM Activities.	1,000,000.00	5 years	1 or 2 research or studies	
Provide scholarship for students of mining and geosciences courses	Universities	Academe	Provide scholarships	1,000,000.00	5 years	Mining and geosciences course graduates	
Support Research by MGB	Region	MGB-13	Assist Research /Project of MGB-13	1,000,000.00	5 years	Regularly pay the annual dues	
Mine Visits of for bench marking by company and regulatory bodies	Anywhere in the Phil	Company staff/community leaders/regulators	Visit to other operating Mines	500,000.00	5 years	For the MRFC and/or MMT members to do annual benchmarking with other mines	
Contingency			Other activities	500,000.00			

Table 5.1.2: Social Development Plan for the IPs of Adlay and Pantukan

CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of fund
Gender Responsive Sec.3 of FPIC Livelihood and Credit Facilities (Men, Women, Youth & elderly) - backyard livestock & vegetable production Sec 4. FPIC Employment Opportunities: mechanics, drivers & other technical jobs	Manobo Datu & Council of Elders and Mamanwa Datu & Council of Elders, IP Affected Men, Women, Youth & Elderly	• NCIP - coordinate • MSWD: SEA KAUNLARAN credit facilities • TESDA/TLRC: Technical training for drivers, mechanics & other technical jobs; Training for new handicraft designs • DA: Training for livestock & vegetable production	4DVDI lead implementor coordinated by Community Relations Officer	Pre-construction Construction Operation	4DVDI FPIC Ph 50,000 1% ICC/IPs 1% ICC/IPs
Health and Safety Sec.3 .FPIC Health services Disaster Management	Manobo & Mamanwa Datu & Council of Elders, Barangay Kagawad for Health	NCIP coordinating MHO Assign health worker Provide medical supplies Barangay Disaster Management training	4DVDI lead implementor coordinated by Community Relations Officer	Pre-construction Construction Operation	4DVDI FPIC Ph 18,000 1% ICC/IPs 1% ICC/IPs

CONCERN	Responsible Community Member / Beneficiary	Government Agency/ Non-government Agency and Services (indicate specific services)	Proponent	Indicative Timeline	Source of fund
Education and Recreation School Building Sec.5. FPIC Scholarships Sec. 6. FPIC	Manobo and Mamamanwa Datu & Council of Elders, Barangay Kagawad for Education	NCIP coordinating DepEd Basic Non- formal Education for the adult & elderly - Formal education for children	4DVDI lead implementor coordinated by Community Relations Officer	Pre-construction Construction Operation	4DVDI FPIC Ph 10,000/yr
Environment and Sanitation -Sec. 12. FPIC Environmental protection and enhancement - Solid Waste Management	Manobo and Mamanwa Datu & Council of Elders, Barangay Kagawad for Environment	NCIP coordinating MPDO/ ENRO - contextual training of solid waste management MHO - training in sanitary practices	4DVDI lead implementor coordinated by Community Relations Officer	Pre-construction Construction Operation	4DVDI
Peace and order Sec. 9 & 10 FPIC ICC rights and interest	Manobo and Mamanwa Datu & Council of Elders Barangay Kagawad for Peace and order	LGU- - Municipal NCIP monitors the implementation of Sec. 9& 10 of the FPIC PNP - coordinates with Municipal NCIP	4DVDI lead implementor coordinated by Community Relations Officer & Chief Security Officer	Pre-construction Construction Operation	4DVDI
Culture Sec. 33 R.A 8371/ FPIC Sec. 10 Respect & protection of ICC culture	Manobo and Mamanwa Datu , & Elders	Municipal NCIP monitors the implementation of Sec.10 of the FPIC	4DVDI lead implementor coordinated by Community Relations Officer	Pre-construction Construction Operation	4DVDI

5.2 IEC FRAMEWORK

The IEC for mining projects is part of the SDMP. It is 15% of the 1.5% of the Operating Cost. IEC will be a continuing process through the life of the project. IEC necessarily involves several media and forms such as perception surveys, public consultation or Focus Group Discussions (FGDs) or print media. The IEC Plan/Framework as SDMP component is shown in **Table 5.2.1**. This IEC Framework is still generic and will be updated through consultations with the concerned stakeholders during the approval of the SDMP.

Table 5.2.1: IEC Plan/Framework

IEC (15 % OF THE 1.5% OF THE OPERATING COST) (P7,00,000.00)							
Publication	Within R-13	Newspaper outlet	Newspaper, Journal, Souvenir Program, Local Tabloid, School Organ and other similar publication either locally and/or Regional.	3,000,000.00	5 years	Publication in local newspaper in coordination with PSEM	
Radio program	Within R-13	Radio stations	Any radio program that will about mining	1,500,000.00	5 years		
Support the IEC of the Mining Industry in R13	Within R-13	Mining industry group	Support the mining industry's initiative in R-13.	2,000,000.00	5 years	Better understanding bout benefits of mining by students	
Contingency			Others	500,000.00			

5.3 GRIEVANCE REDRESS MECHANISM

In order to avoid conflict and misunderstanding among employees and the community, 4DVDI implements the following mechanism:

- Grievance hotline in different Departments to report any suspected violation in the Code of Ethics or any concerns
- Regular coordination with barangays thru meetings
- Provision of Bulletin Boards at the mine site and in the barangays
- Reporting to LGU on any issue or concern to the barangays and/or to the LGU of the Municipal Government of Carracal and Claver
- Dedicated Resident Manager who also acts as Community Relations Officer

6. ENVIRONMENTAL COMPLIANCE MONITORING

6.1 SELF-MONITORING PLAN

4DVDI will conduct a self-monitoring activity of its environmental operations, and will regularly submit its Self-Monitoring Report (SMR) to the DENR. The initial Environmental Monitoring Plan (EMoP) will follow Annex 2-20 of the DAO 2003-30. The EMoP is presented in **Table 6.1.**1.

Table 6.1.1: Environment Monitoring Plan

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
Construction Phase													
• Pit Planning and surveying • Site Clearing • and overburden removal • Field office and motor pool construction • Access road construction • Drainage canal and Settling pond construction	• Vegetation removal and loss of habitat • Threat to existence and loss of important local species • Threat to abundance, frequency and distribution of important species	Diversity and species richness (Abundance and Frequency)	Quadrat sampling for flora and transect monitoring for fauna	Semi annual	Within the tenement area and vicinity	MEPEO Officer/ PCO Third party consultant	Include in MEPEO Budget	30% abundance and frequency reduction of flora along the monitoring stations 30% reduction of abundance and frequency of common and endemic avian species observed on site as based on the baseline data	40% abundance and frequency reduction of flora along the monitoring stations 40% reduction of abundance and frequency of common and endemic avian species observed on site as based on the baseline data	50% abundance and frequency reduction of flora along the monitoring stations 50% reduction of abundance and frequency of common and endemic avian species observed on site as based on the baseline data	Assess extent of vegetation clearing and identify areas within the EP for reforestation Use indigenous and native species as well as fruiting trees reforestation species Minimize revving-up of vehicles and heavy equipment	Establish green corridors and shelterbelts Conduct immediate rehabilitation once mined out Establish off-limit zone for vehicles along areas identified as conservation areas and shelterbelts	Assess areas prone to soil creep or landslide and stabilize slope area and rehabilitate Institute biodiversity offset areas Conduct enrichment planting with emphasis on Assisted Natural Regeneration (ANR)
	• Soil erosion, loss of topsoil/ overburden	Volume of topsoil conserved and	• Record keeping of topsoil volume	Semi annual	Within the tenement area and vicinity	MEPEO Officer/ PCO	Include in MEPEO budget	Volume of topsoil conserved is less than 70%	Volume of topsoil conserved is less than 60%	Volume of topsoil conserved is less than 50%	Notify heavy equipment operator to set aside	Implement volume quota to heavy equipment	Future acquisition of topsoil from adjoining areas

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		integrity of stockpile	conserved • Inspection of stockpiles to check for soil erosion • Mapping of storage sites					of the estimated volume needed for future rehabilitation	of the estimated volume needed for future rehabilitation	of the estimated volume needed for future rehabilitation	topsoil and identify additional storage area	operator to set aside top soil and maximize additional storage area	to be used for rehabilitation
		Rate of erosion	• Photo-documentation • Use of bottle caps (caps protects soil underneath and form pillar overtime; height of pillar will indicate erosion rate) • Use of erosion monitoring box	Monthly	Within and adjacent to construction sites	MEPEO Officer/ PCO	Include in MEPEO budget	Presence of several rill erosion along cleared areas	Presence of gullying along cleared areas	Occurrence of severe erosion, soil creep and landslide	Construction of drainage canal to divert storm run-off	Implementation of slope stabilization techniques	Installation of gabions and engineering techniques to control severe erosion
	Soil contamination due to generation of solid and hazardous waste	Volume of solid and hazardous waste generated	Record keeping of generated solid and hazwaste, mode of disposal and volume disposed or recycled	Monthly	Within and adjacent to construction sites	MEPEO Officer/ PCO DENR-accredited hazwaste transporter	Include in MEPEO budget	Foul odor from waste disposal site	Sighting of pest such as rats and roaches	Spread of disease to surrounding areas	Review of housekeeping practices when pests are present at the holding areas	Pest eradication Immediate cleanup of the temporary storage site and	All waste from the kitchen should be contained. Compost pit should be covered

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
											Continuous collection, treatment and disposal by DENR-accredited hazwaste treater	disposal accumulated wastes Immediate disposal or treatment of hazardous wastes	Use of environmental friendly materials
	Degradation of surface water quality	Color, TSS, pH and heavy metals (Mn, As, Cd, Pb and Ni)	In-situ sampling , grab sampling and laboratory analysis	Monthly	At rivers and streams draining the proposed mine site	PCO Third party consultant	Include in MEPEO budget	Freshwater body •TSS –64 mg/L •Mn – 0.16 mg/L •As –0.016 mg/L •Pb – 0.04 mg/L •Ni – 0.16 mg/L	Freshwater body • TSS – 72 mg/L • Mn – 0.18 mg/L • As – 0.018 mg/L • Pb – 0.0450 mg/L • Ni – 0.18 mg/L	DENR Standard Limit for Class C as stipulated in DAO 2016-08 • If pH is lower than 6.5 or higher than 9 • TSS – 80 mg/L • Mn – 0.2 mg/L • As – 0.02 mg/L • Cd – 0.005 mg/L • Pb – 0.05 mg/L • Ni – 0.2 mg/L	Reconsider design runoff flow rate and rate of particle settlement of the silt ponds to ensure effectiveness	Addition of embankment and other flood control measures for the reduction of runoff flowrate and containment of runoff	Immediate desilting of silt ponds Establishment of additional silt pond

Key Environmental Aspects per Project Phase	**Potential Impacts Per Environmental Sector**	**Parameter to be Monitored**	**Method**	**Freq.**	**Location**	**Lead Person**	**Annual Estimated Cost in PhP**	**EQPL Management Scheme**					
								EQPL Range			**Management Measure**		
								Alert	**Action**	**Limit**	**Alert**	**Action**	**Limit**
	Degradation of air quality	Ambient PM_{10}, TSP, SO_x, and NO_x	24-hour ambient air monitoring for PM-10, TSP, SO_x, and NO_x	Quarterly		PCO Third party consultant	Include in MEPEO budget	• SO_x – 144.5 µg/Ncm • NO_x – 120.5 µg/Ncm • TSP – 184.5 µg/Ncm • PM-10 – 120.5 µg/Ncm	• SO_x – 162.5 µg/Ncm • NO_x – 135.5 µg/Ncm • TSP – 207.5 µg/Ncm • PM-10 – 135.5 µg/Ncm	DENR Standard Limit as stipulated in the IRR of Clean Air Act • SO_x – 180 µg/Ncm • NO_x – 150 µg/Ncm • TSP – 230 µg/Ncm • PM-10 – 150 µg/Ncm	Identification of possible source of pollutant	Temporarily halt operation and do corrective measures Conduct of maintenance of equipment/ machinery identified as the source of pollution Increase frequency of water spraying	Stop operations and resume only when corrective measures were in place Replace equipment that emits high concentration of pollutants or use better fuel Increase frequency of water spraying
	Increase in ambient noise level	Sound level (db)	24-hour sound measurement using hand-held sound meter Noise Meter	Monthly	construction area and residential areas	PCO	Minimal cost	3 dB less than limit	2 dB less than limit	1 dB less than limit	Identification of possible source of noise Issuance of ear plugs	Maintenance, adjustment or replacement of mufflers and installation of noise reduction apparatus	Change of equipment or noise minimization device Limit operations during daytime hours
	Threat to workers / public health and safety	Safety record, accident/ fatality incidence/ occurrence	Record keeping	Daily	construction area	Safety officer	Minimal cost	Increase in frequency of non-lost time accident	Occurrence of nonfatal lost time accident	Occurrence of fatal lost time accident	Conduct quarterly safety briefing and orientation	Conduct daily inspection of construction area	Work stoppage along accident area and identify

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
											to laborers and workers Installation of safety signages along accident prone areas within the constructio n site	Conduct daily briefing on safety program	proper safety measures and implement specific safety procedures and protocol
	Social impacts	Number of jobs generated for locals, training programs and other social development programs	Record keeping	Monthly	Barangays Diaz, Imelda, Mabini, Navarro and Sta. Cruz and secondary impact areas	MEPEO officer/ PCO and ComRel	Minimal cost	Number of locally hired employees fall down to less than 40% of the total workforce SDMP accomplishm ent falls below 80% of targets	Number of locally hired employees fall down to less than 20% of the total workforce SDMP accomplish ment falls below 60% of targets	No locals are employed by the company in the last six months SDMP accomplish ment falls below 40% of targets	Review hiring policies Review SDMP programs and determine reasons for the poor implementatio n of the program	Implement more skills training program to empower residents Identify alternatives for the SDMP program to improve accomplishm ent	
	Complaints	Number of valid complaints	Record keeping	Daily	construction site	MEPEO officer/ PCO and ComRel	Minimal cost for record keeping	Formal complaint submitted can be resolved at the ComRel level	Intervention from the Upper Manageme nt is needed to resolve a formal complaint	Complaint is broadcaste d over mass media	Institution of grievance system Conduct regular IEC to inform and justify the	Notify 4DVDI Admin for complaint and take remedial measures to address complaints	Conduct in depth investigation and identify root cause for all valid complaints

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
											activities being undertaken by 4DVDI during construction	Investigate all complaints, conduct dialogue with communities and implement mitigating measures Compensate affected communities	Institute measures to avoid occurrence of similar problems
Operations Phase													
• Mining Operation • Transport of ores • Waste material handling •	• Vegetation removal and lost of habitat • Threat to existence and loss of important local species • Threat to abundance, frequency and distribution of important species	Diversity and species richness	Quadrat sampling for flora and transect monitoring for fauna	Semi annual	Within and adjacent to mining area	MEPEO Officer/ PCO Third party consultant	Include in MEPEO budget	30% abundance and frequency reduction of flora along the monitoring stations 30% reduction of abundance and frequency of common and endemic avian species observed on site as based on the baseline data	40% abundance and frequency reduction of flora along the monitoring stations 40% reduction of abundance and frequency of common and endemic avian species observed on site as based on the baseline data	50% abundance and frequency reduction of flora along the monitoring stations 50% reduction of abundance and frequency of common and endemic avian species observed on site as based on the baseline data	Assess extent of vegetation clearing and identify areas within the EP for reforestation Use indigenous and native species as well as fruiting trees reforestation species	Establish green corridors and shelterbelts Conduct immediate rehabilitation once mined out	Assess areas prone to soil creep or landslide and stabilize slope area and rehabilitate Institute biodiversity offset areas

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		Survival rate of seedlings	Survey and performance monitoring	Semi annual	Within and adjacent to mining area	MEPEO Officer/ PCO Third party consultant	Include in MEPEO budget	If survival rate is 80%	If survival rate is 70%	If survival rate is 50%	Assessment of planting area condition to include possible infestation/ ascertain debilitating factors	Restocking or replanting seedlings	Immediate assessment of soil viability and if necessary soil amelioration should be done prior to planting
	Generation of solid waste	Volume of solid waste generated including volume recycled and disposed to the landfill	Estimation o volume	Weekly	Within and adjacent to mining area	MEPEO Officer/ PCO Third party consultant	Include in MEPEO budget	Foul odor from waste disposal site	Sighting of pest such as rats and roaches	-	Review of housekeeping practices when pests are present at holding areas Spread of disease to surrounding areas	Pest eradication Immediate cleanup of the temporary storage site and disposal of accumulated wastes	All waste from the kitchen should be contained Compost pit should be covered
	Degradation of surface water quality	<u>Effluent</u> pH, TSS, Mn, As, Cd, Pb and Ni <u>Freshwater body</u> pH, TSS and heavy metals (Mn, As, Cd, Pb and Ni)	In-situ sampling, grab sampling and laboratory analysis	Monthly	<u>Effluent</u> Siltation ponds <u>Freshwater body</u>			<u>Effluent</u> • TSS – 85 mg/L • Mn – 1.7 mg/L • As – 0.034 mg/L • Cd – 0.0085 mg/L • Pb – 0.085	<u>Effluent</u> • TSS – 90 mg/L • Mn – 1.8 mg/L • As – 0.036 mg/L • Cd – 0.009 mg/L • Pb – 0.095	DENR Standard Limit for Effluent as stipulated in DAO 2016-08 (Class C) • If pH is lower than 6.0 or higher than 9.5	Reconsider design runoff flow rate and rate of particle settlement of the silt ponds to ensure effectiveness	Addition of embankment and other flood control measures for the reduction of runoff flowrate and containment of runoff	Immediate desilting of silt ponds Establishment of additional silt pond

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
								mg/L • Ni – 0.85 mg/L <u>Freshwater body</u> • TSS –64 mg/L • Mn – 0.16 mg/L • As –0.016 mg/L • Pb – 0.04 mg/L • Ni – 0.16 mg/L	mg/L • Ni – 0.9 mg/L <u>Freshwater body</u> • TSS – 72 mg/L • Mn – 0.18 mg/L • As – 0.018 mg/L • Pb – 0.0450 mg/L • Ni – 0.18 mg/L	• TSS – 100 mg/L • Mn – 2 mg/L • As – 0.04 mg/L • Cd – 0.01 mg/L • Pb – 0.1 mg/L • Ni – 1 mg/L DENR Standard Limit for Class C as stipulated in DAO 2016-08 • If pH is lower than 6.5 or higher than 9 • TSS – 80 mg/L • Mn – 0.2 mg/L			

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
										• As – 0.02 mg/L • Cd – 0.005 mg/L • Pb – 0.05 mg/L • Ni – 0.2 mg/L			
	Impact on freshwater biology	Species richness of freshwater organisms -Fish -Macro Vertebrates -Plankton -Benthos	Limnological assessment and plankton sampling using plankton net	Semi annual	River	MEPEO Officer/ PCO Third party consultant	Include in MEPEO budget	30% abundance and frequency increase in Chlorophytes and Euglenophytes and prevalence of Chironomids.	40% abundance and frequency increase in Chlorophytes and Euglenophytes and prevalence of Chironomids. Presence of Nematodes and slime like algal blooms.	50% abundance and frequency increase in Chlorophytes and Euglenophytes and prevalence of Chironomids Year-round presence of slime like algal blooms.	Observation of frequency and extent of siltation and identify sources of silt Investigate source of nutrient rich waters	Temporarily stop effluent discharge and conduct investigation	Stop mine operations
	Impact on marine biology	Species richness of marine organisms Fish Corals Seagrass plankton	Underwater survey Field sampling	Semi annually	Mouth of the river	MEPEO PCO	Include in MEPEO budget	High siltation of marine waters specially along the pier and at the mouth of the river	Continuous siltation even after periods of rain	Decrease in species diversity along stations Occurrence of algal bloom	Observation of frequency and extent of siltation Identification of sources of silt	Improve efficiency of silt ponds by conducting maintenance or construction of	Stop mine operations and install additional silt ponds and check dams to manage siltation of rivers

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
												additional ponds Intensify mangrove planting along the river mouths	
	Groundwater contamination	pH, TDS, hardness, turbidity, Total and Fecal coliform and heavy metals such Mn, As, Cd, Pb and Ni	Grab sampling and laboratory analysis	Monthly	Community wells located at the impact areas	MEPEO Officer/ PCO	Include in MEPEO budget	• TDS – 400 mg/L • Hardness - 240 (as $CaCO_3$) • Mn – 0.36 mg/ • As – 0.04 mg/L • Cd – 0.002 mg/L • Pb – 0.006 mg/L • Ni – 0.016 mg/L	• TDS – 450 mg/L • Hardness - 270 (as $CaCO_3$) • Mn – 0.38 mg/L • As – 0.045 mg/L • Cd – 0.0025 mg/L • Pb – 0.008 mg/L Ni – 0.018 mg/L	DENR Standard Limit as stipulated in PNSDW • pH 6.5 – 8.5 • TDS – 500 mg/L • Hardness - 300 (as $CaCO_3$) • Mn- 0.4 mg/L • As – 0.05 mg/L • Cd – 0.003 mg/L • Pb – 0.01 mg/L • Ni – 0.02 mg/L	Map out location of contaminated or groundwater sources and observed for one quarter Determine possible sources of contamination	Abandon groundwater resources	Stop min operations
	Generation of solid and hazardous waste	Volume of solid, oil sludge hazardous	Record keeping o generated solid and hazwaste, mode o	Monthly	Hazardous waste storage facility	MEPEO Officer/ PCO	Include in MEPEO budget	Accumulation of solid and	Evidence of leakage, spillage or	Complaints from workers	Continuous collection, treatment and	Reduction on the use of raw materials	Use of alternativ materials whic are mor

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		waste generated	disposal and volume disposed or recycled			DENR-accredited hazwaste transporter		hazardous wastes	signs of damage of hazardous waste containers	and laborers	disposal by DENR-accredited hazwaste treater	which are potential source of hazardous wastes Immediate disposal or treatment of hazardous wastes	environment friendly
	Degradation of air quality	Ambient PM_{10}, TSP, SO_x, and NO_x	24-hour ambient air monitoring for PM_{10}, TSP, SO_x, and NO_x	Quarterly	Established monitoring stations	PCO	Include in MEPEO budget	• SO_x – 144.5 µg/Ncm • NO_x – 120.5 µg/Ncm • TSP – 184.5 µg/Ncm • PM-10 – 120.5 µg/Ncm	• SOx – 162.5 µg/Ncm • NOx – 135.5 µg/Ncm • TSP – 207.5 µg/Ncm • PM-10 – 135.5 µg/Ncm	DENR Standard Limit as stipulated in the IRR of Clean Air Act • SOx – 180 µg/Ncm • NOx – 150 µg/Ncm • TSP – 230 µg/Ncm • PM-10 – 150 µg/Ncm	Identification of possible source of pollutant Use of tarpaulin to cover ore during hauling	Temporarily halt operation and do corrective measures Conduct of maintenance of equipment/ machinery identified as the source of pollution Increase frequency of water spraying	Stop operations and resume only when corrective measures were in place Replace equipment that emits high concentration of pollutants or use better fuel Increase frequency of water spraying
	Increase in ambient noise level	Sound level (db)	24-hour sound measurement using hand-held sound meter Noise Meter	Monthly	Established monitoring stations	PCO	Minimal cost	3 dB less than limit	2 dB less than limit	1 dB less than limit	Identification of possible source of noise	Maintenance, adjustment or replacement of mufflers and	Change of equipment or noise minimization device

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
											Issuance of ear plugs	installation of noise reduction apparatus	Limit operations during daytime hours
	Threat to workers / public health and safety	Safety record, accident/ fatality incidence/ occurrence	Record keeping	Daily	mining area, haulage roads, stockyard and pier site	Safety officer	Minimal cost	Increase in frequency of non-lost time accident	Occurrence of nonfatal lost time accident	Occurrence of fatal lost time accident	Conduct quarterly safety briefing and orientation to laborers and workers Installation of safety signages along accident prone areas within the construction site	Conduct daily inspection of construction area Conduct daily briefing on safety program	Work stoppage along accident area and identify proper safety measures and implement specific safety procedures and protocol
	Social impacts	Number of jobs generated for locals; training programs; and other social development programs	Record keeping; Social Impac Assessment	Monthly Every five (5) years for SIA	Host communities and secondary impact areas	MEPEO officer, PCO and ComRel Third party consultant	Minimal cost	Number of locally hired employees fall down to less than 40% of the total workforce SDMP accomplishment falls below 80% of target	Number of locally hired employees fall down to less than 20% of the total workforce SDMP accomplishment falls below 80% of target	No locals are employed by the company in the last six months SDMP accomplishment falls below 40% of target	Review hiring policies Review SDMP and determine reasons for the poor implementation of the program	Implement more skills training program to empower residents Identify alternatives for the SDMP projects to improve accomplishment	Stop min operations
	Complaints	No. of valid complaints	Record keeping	Daily	Host	MEPEO	Minimal cost	Formal complaint	Intervention from the	Complaint is broadcasted	Institution of	Notify 4DVDI Admin for	Conduct in depth

Key Environmental Aspects per Project Phase	Potential Impacts Per Environmental Sector	Parameter to be Monitored	Method	Freq.	Location	Lead Person	Annual Estimated Cost in PhP	EQPL Management Scheme					
								EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
					communities and secondary impact areas	officer, PCO and ComRel		submitted can be resolved at the ComRel level	Upper Management is needed to resolve a formal complaint	over mass media	grievance system Conduct regular IEC to inform and justify the activities being undertaken by 4DVDI during construction	complaint and take remedial measures to address complaints Investigate all complaints, conduct dialogue with communities and implement mitigating measures Compensate affected communities	investigation and identify root cause for all valid complaints Institute measures to avoid occurrence of similar problems

6.2 MULTI-PARTITE MONITORING TEAM

Pursuant to Sections 174 and 185 of DENR Administrative Order No. 2010-21 (DAO 2010-21), the Revised Implementing Rules and Regulations of Republic Act No. 7942 (RA 7942), otherwise known as the "Philippine Mining Act of 1995", Multi-Partite Monitoring Team (MMT) shall be formed. The MMT is tasked to monitor the compliance of the project as stated in the ECC conditions, EMP and other related policy. Moreover, DAO 2017-15 also states that the vigilance of the public especially stakeholders living or working near the project site shall be used as tool in effectively monitoring and managing environmental impacts of projects. The MMT is the monitoring arm of the Mine Rehabilitation Fund Committee (MRFC). The head of the MMT shall submit to the MRFC, at least five (5) working days before the scheduled regular meetings of the MRFC, a report on the status and/or result of its monitoring activities on the performance of and compliance with the approved EPEP/AEPEP by the concerned Mining Contractor/Permit Holder.

6.3 ENVIRONMENTAL MONITORING AND GUARANTEE FUND COMMITMENT

For resource extractive projects where this project of 4DVDI falls, a financial mechanism called Contingent Liability and Rehabilitation Fund (CLRF) is established in lieu of the EMF and EGF. The CLRF is an environmental guarantee fund mechanism that ensures the just and timely compensation for damages and progressive and suitable rehabilitation for any adverse effect a mining operation or activity may cause. This fund is further broken down as follows:

- Mine Rehabilitation Fund (MRF) which is divided into Rehabilitation Cash Fund (RCF) and Monitoring Trust Fund (MTF);
- Mine Waste Tailings Reserve Fund (MWTRF); and
- Final Mine Rehabilitation and Decommissioning Fund (FMRDF).

4DVDI will commit an RCF to comply with the regulation under Consolidated DENR Administrative Order (CDAO) No. 2010-21 which stated that *"The RCF shall be equivalent to ten percent (10%) of the approved total amount needed to implement the EPEP or Five Million Pesos (Php 5,000,000.00) whichever is lesser."* (Note: EPEP is still for approval by the CLRFSC and MGB).

For the MTF shall be in cash and in an amount to be determined by the MRF Committee which shall not be less than the amount of One Hundred Fifty Thousand Pesos (PhP150,000.00) to cover maintenance and other operating budget for the transportation and travel expenses, cost of laboratory analysis, cost of supplies and materials, cost of communication services, cost of consultancy work and other reasonable expenses incurred by the monitoring team: *Provided*,That the Secretary shall be authorized to increase the said amount when national interest and public welfare so require, upon the recommendation of the Director. The Contractor/Permit Holder shall notify the Chair or the Co-Chair of the MRF Committee of its compliance with the deposit requirement through a certification from the bank.

For the FMRDF, the amount to be deposited will be compliant with the required minimum amount under CDAO No. 2010-21 to ensure that the full cost of the approved FMR/DP is accrued before the end of the operating life of the mine. The FMRDF shall be deposited as a trust fund in a Government depository bank and shall be used solely for the implementation of the approved FMR/DP.

7. DECOMMISSIONING/ABANDONMENT/ REHABILITATION POLICY

The project will be abandoned after the laterite deposit had been exhausted, possibly after more than 10 years. Pursuant to Section 187 of DENR Administrative Order (DAO) 2010-21, 4DVDI shall prepare and submit an integrated Environmental Protection and Enhancement Program (EPEP) and Final Mine Rehabilitation and/or Decommissioning Plan (FMRDP) to the Mine Rehabilitation Fund (MRF) Committee and Contingent Liability Rehabilitation Fund (CLRF) Steering Committee, through the Regional Office concerned and the MGB Central Office, respectively.

The FMRDP shall be prepared in consistent with the provisions and relevant rules and regulations of the Philippine Mining Act of 1995. The FMRDP shall include but not limited to the following:

- Description of the project and its various facilities as well as reasons for abandonment and schedules of phase-out or abandonment;
- Assessment reports made on aspects concerning the environmental, social, and public health;
- Options or alternatives for the host communities including its workers so that only minimal dislocation will result from the decision to abandon the project;
- Mapped rehabilitation program for mined-out areas;
- Environmental, social and economic projections of host communities years after the abandonment of the project;
- Cost of mine closure plan indicating the mine rehabilitation cost per activity and a schedule of payment of the FMRD Fund;
- Monitoring plan to evaluate the effectiveness of the closure and final rehabilitation measures; and
- Proper disposal of any residual toxic material in the heavy equipment shop and other areas of concern and the stabilization of the dump sites/landfills.

An Annual EPEP shall also be submitted to the MGB. The Annual EPEP shall contain discussion on the nature and extent of the project such as ore reserves, transportation, power supply, list of equipment used in mining operations, workforce information, and development schedule. It shall also discuss the specific strategies that are being implemented to limit and control the possible impacts of the project to the environment.

8. INSTITUTIONAL PLAN FOR EMP IMPLEMENTATION

This section provides the instrument required to establish a proactive institutional requirement to guarantee compliance with environmental regulations and policies and implementation of environmental safeguards and commitments. It is important to set up capable and competent unit/group with properly defined roles in the process of the monitoring and evaluation of post EIA requirements and commitments as well as with other environmental regulations. It is important to identify and provide the group that will implement said requirements for a sustainable project operation.

8.1 FUNCTION

The mining operation of 4DVDI is guided by the principle of "sustainable development" as it promotes socio-economic progress, environmental management, pollution control, safety among employees and community residents, healthy lifestyle and good relationship with the stakeholders. The Safety, Health, Environmental, and Social (SHES) Department of 4DVDI will be responsible for the environmental performance of the project. It ensures implementation of the environmental safeguards and controls for the project implementation (for all phases of the project) and is responsible for overseeing environmental compliance activities, environmental requirements, and regulatory obligations.

Core Function of the SHES Department includes the following:

- Systems and Procedures
- Environmental Safeguards and Implementation
- Government Regulatory Compliance
- Environment Health Safety Program and Awareness
- EHS Program Compliance

8.2 SETUP

In many cases, the SHES Department leads the post EIA compliance and implementation process in collaboration with the other technical team/groups to provide technical support. **Figure 8.2.1** illustrate the institutional framework for the proposed project. There are no generally applicable, rigid rules, so many variations are possible depending on the personnel capacities and structures.

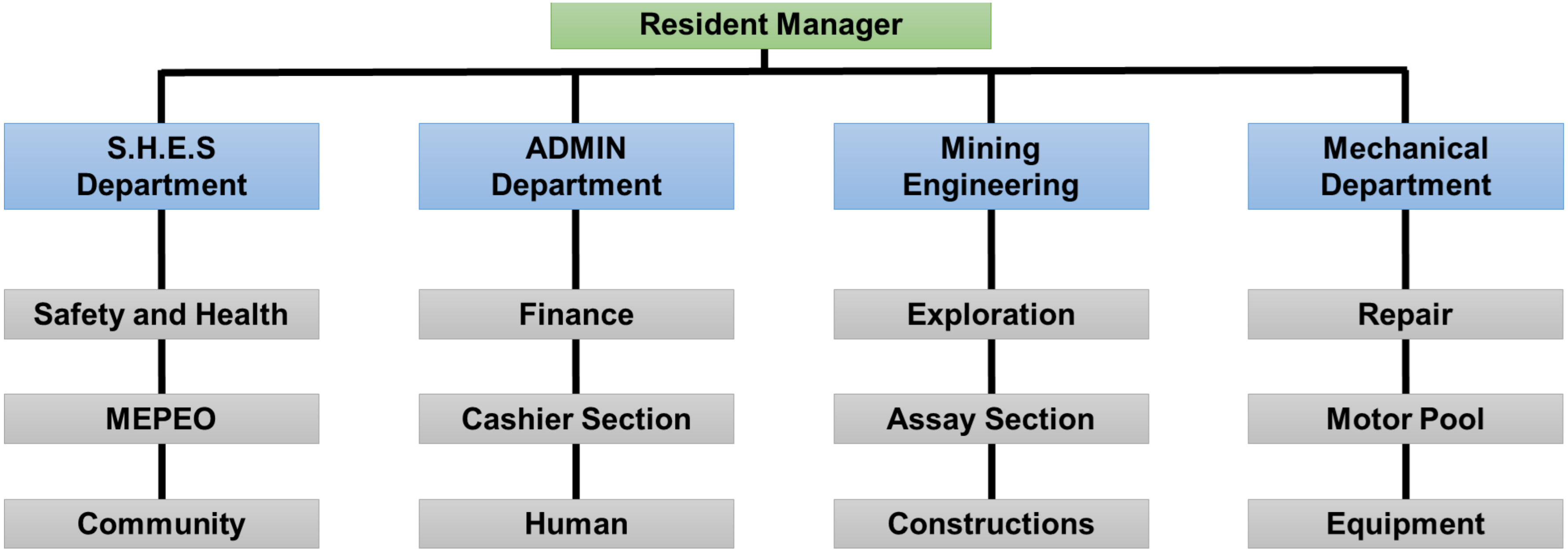


Figure 8.2.1: Proposed Organizational Structure of 4DVDI

8.3 ROLES AND RESPONSIBILITIES

Table 8.3.1 provides the brief description of the role and responsibilities of the key personnel, the technical team, and collaborating units/groups in the implementation of the EMP.

Table 8.3.1: Roles and Responsibilities of Key Personnel and Departments

Department/Key Personnel	Roles and Responsibilities
Resident Manager	Oversees the over-all operations of the mining area and the general management of the day-to-day activities of the mining operations. All Department Heads reports to him.
SHES Department	This department is responsible for the following: • overall environmental performance of the project; • compliance to environmental regulations and standards; • maintenance of reports that are submitted to internal and external agencies; • implementation of emergency response procedures, handling of hazardous materials and environmental management systems and requirements of DOLE on occupational safety and health; and • community relations, design, training and implementation of CSR and SDP programmes
ADMIN Department	Administrative Department is a unit to be assigned with various responsibilities concerning personnel, finance, publications, public relations, conferences, sale of documents and similar administrative functions; in particular: • Personnel affairs; • Organization of training of officials and supervision of programs established to that effect; • General services including the general register of the staff and services; • Rendering consultations to other departments on organizational matters; • Preparation of studies on the administrative organization; • Maintaining and auditing the accounts of the company; • Supervision of storage and purchasing; • Preparation of the budget; • Organization of administrative services for conferences and meetings; and • Maintaining and organization of the library and the archives as well as their use.
Mechanical Department	This department is in charge of the following: • automation control, optimization, safety and testing of necessary support needed by the project; • schedule and regular inspection; and • maintenance and repair of equipment.
MMT	The MMT is also included as part of the EMP implementation mechanism because it has the primary role of monitoring the project's implementation of the committed EMP. The responsivity of the MMT shall be as follows: • Monitor project compliance with the conditions stipulated in the ECC and commitments made in the EMP using checklist form and mainly secondary technical information and primary observations; • Prepare, integrate, and disseminate simplified monitoring reports and submit recommendations to the DENR; • Monitor implementation of community IEC plan/program and SDP; • Interface with the technical third party audit group to understand and be updated on Monitoring and Evaluation results; • Initiate popularization of Monitoring and Evaluation results for community consumption; and • Officially receive complaints/requests from the public-at large for transmittal to 4DVDI and EMB-DENR and be able to recommend immediate measures against the complaint.

8.4 SKILLS AND COMPETENCY

Selection of competent and effective personnel comprising the environmental unit will be crucial in the institutional or organization building. Qualifications for the members may include the following:

- Understanding of environment management, legal regulatory framework, environmental impact assessment and reporting, and environmental compliance and audit management. Well-versed and familiar with the application of local laws and regulations on Environmental regulatory compliance.
- Experience in integrated environmental assessment
- Good relationship with the environmental regulatory authority
- Capacity to dialogue with different stakeholders from both the public and private sector, and ability to build consensus on key environmental issues
- Oral and written communication skills; people skills; project coordination; monitoring and audit; scientific research and development; project planning; policy formulation; and training and facilitation.

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