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EXECUTIVE SUMMARY

A. PROJECT FACT SHEET

I. Project Information

Project Name / Title	:	WESTCHINAMIN ZAMBALES FERRO-NICKEL PLANT AND MINING PROJECT
Project Location	:	Barangay of Uacon, Malimanga, Taposo, Yamot, Sibacan, Malabon at Pinagrealan, Minicipality of Candelaria and Barangay Guinabon Minicipality of Sta. Cruz province of Zambales
Project Components	:	1. Ferro-Nickel Plant and Facilities 2. Mining within the following Parcels

MPSA No. 316-2010-III, Amended I	Ha.
Parcel 1 **(existing)**	286.2500
Parcel II	164.7884
Parcel VII	1,483.3508
Parcel VIII	82.4208
Total	**2,016.81**

3. Support Facilities/Infrastructure
   a) Access and Mine roads
   b) Solar Farm for a 48MW
   c) Gen Set 30 MW
   d) Camp Facilities

      a. Assay Laboratory - housed the equipment in assaying the different grade of the ore
      b. Core house- stockpile for core samples
      c. Staff House – living quarters of some personnel
      d. Guest House – receiving quarters for guest

e. Environment and Community Development Office
f. Mine Engineering Office
g. Motor pool – to be used for maintenance of vehicles and equipment.

II. Project Proponent Profile

Project Proponent	:	**WESTCHINAMIN CORPORATION**
Contact Person	:	Mary Grace M. De Leon President
Address	:	Penthouse, S & L Bldg., Esteban Street Corner De La Rosa Street, Legaspi Village, Makati City
Telephone Nos.	:	(+632) 706 7488; (+63) 977 324 7781
Email address	:	mgdeleon1030@gmail.com

III. Project Preparer

AXceltechs Inc.

Address	Unit 10C, Lansbergh Place, 170 Tomas Morato, Quezon City
Authorized Representative/ Contact Person(s)	**ENGR. PAULO NONI T. TIDALGO** Managing Director
Contact Number	(02) 376-0043

IV. Existing and Proposed Components

The issued ECC includes the operation of Nickel mining covering a total area of 286.25 has. with an annual capacity of 1,000,000 WMT/y. The proposed expansion covers the installation and operation of a Ferro-Nickel Plant and mining of Nickel Ores confined in 1,730.56 has. The Annual mining production would be 3,000,000 metric tons nickel laterite ore with the proposed plant producing 300,000 MT Fe-Ni pellets at 100% plant capacity. A 48 hectares solar farm will also be established to provide the power requirement of the Project.

B. PROCESS DOCUMENTATION OF THE CONDUCT OF ENVIRONMENTAL IMPACT ASSESSMENT

The terms of reference used for this Environmental Impact Assessment (EIA) was consistent with that stipulated in the Revised Procedural Manual (RPM) for Department of Environment and

Natural Resources (DENR) Administrative Order (DAO) No. 2003-30, Implementing Rules and Regulations of Presidential Decree No. 1586 "*Establishing the Philippine Environmental Impact Statement System*".

The Environmental Performance Report and Management Plan (EPRMP) Team is comprised of multi-disciplinary specialists/experts who have extensive training and experience on their respective fields and in the conduct of EIA for various industry sectors.

I. EPRMP Team

This study is a conglomeration and integration of the various technical, environmental, institutional/legal, and social inputs and findings of the following specialists/experts:

EPRMP Team Member	Field of Expertise/Module	Registration
Paulo Noni T. Tidalgo, EM, RN	Environment, ERA, Mining and Geology	IPCO - 103
Bernardo V. Valmonte, Jr. EM	Geology	IPCO - 0723
Dr. Wilfredo Sanidad	Soil Quality	IPCO - 139
Catherine L. Addawe, AgE	Water Quality and Hydrology	IPCO - 055
Roland Pahunang, ChE	Air and Noise Quality, Risk Assessment	IPCO-173
Thelma D. Dela Cruz, DVM, MSc(Env.Sci), MOH	Environmental Risk Assessment	IPCO-387
Thomas V. Tanedo	Terrestrial	IPCO-112
Jess M. Addawe	GIS	IPCO – 056
Czarina May M. Olores, SE	Coordinator	IPCO – 075

II. EIA Study Schedule and Area

The technical scoping was held last 23 April 2018, which was participated by DENR Environmental Management Bureau (EMB) personnel, EIA Review Committee members, WestChinaMin Corporation and Axceltechs Inc.

Activitiy(ies)	Date
Public Scoping	April 11, 2018
Technical scoping	April 23, 2018
Soil Sampling	May 11 – 12, 2018
Water Sampling	May 11 – 12, 2018 June 6 – 8, 2018
Social Survey/Assessment	May 28 – June 1, 2018
Terrestrial Survey	June 9 -11, 2018
Air Sampling	May 11 – 12, 2018
Marine Ecology	June 6 – 8, 2018

Activitiy(ies)	Date
Freshwater Ecology	June 9 -11, 2018

The direct and indirect impact areas of the proposed expansion are based on the result of the assessment of the monitoring and basline data. The identification of direct impact area was based on DAO 2017 – 15. The table below presented the summary of Direct Impact Areas based on the current and proposed expansion:

Aspect	Direct Impact Area
Water	- Receiving water bodies of the project - Underlying aquifer
Air	- Area near the periphery of the plant and mining area
Noise	- Area within the pheriphery of the plant and mining area
Terrestrial	- Vegetated portion within the project area coverage
People	- Barangay of Uacon, Malimanga, Taposo, San Roque, Sibacan, Lauis, Malabon and Pinagrealan, Municipality of Candelaria, and Barangay Guinabon Minicipality of Sta. Cruz

III. EIA Methodology

Primary and secondary data were utilized for the assessment of the project impacts. Primary data were obtained from the conducted on-site investigation and field sampling/surveys while secondary data were acquired from the proponent and government agencies/institutions. Relevant and previously conducted studies were also considered. The following are the sampling/assessment methodologies employed by the EPRMP team for the study:

Module		Methodology
Land	Land Use	Gathering and review of secondary data
	Natural Hazards	Gathering and review of monitoring and secondary data
	Pedology	Grab sampling and laboratory analysis
	Terrestrial	Transect walk, quadrat sampling, trapping and review of monitoring data
Water	Hydrology and Hydrogeology	Gathering and review of monitoring and secondary data
	Water Quality	In-situ measurements; grab sampling and laboratory analysis

Module		Methodology
	Marine Ecology	Gathering and review of monitoring and secondary data. Conduct of Marine Ecology Baseline Data Gathering
Air and Noise	Meteorology	Gathering and review of secondary data
	Air and Noise Quality	Gravimetric, Colorimetric-Pararosaline, Griess-Saltzman NDIR, Atomic Absorption Spectrophotometry, Trace metals, Sound level meter for noise and review of monitoring data
People	Socio-economic Profile	Gathering and review of monitoring and secondary data Key informant interviews Perception survey Focus group discussions

IV. Public Participation

The Public Scoping was conducted last April 11, 2018 at Candelaria Multipurpose Gym (Covered Court), Candelaria, Zambales. The following are the issues and concerns raised during the Public Scoping:

Module	Issues/Concerns	Person who raised the issue	Response from the Proponent/Preparer/EMB
Project Description	Pa ano mamanage ang waste product ng planta?	Mayor Napoleon E. Edquid	Zero Waste technology. Gagawin construction materials at slope protection (grouting at shotcreting).
	Mag provide ng hard copy ng presentation para mas ma intindihan ng mga tao ang proyekto	Pete Oco	Engr. Carlo Arida EMB – Available ang project description and presentation sa website ng EMB. Ma aari rin kayong magpadala ng komento sa aming email.
	Hindi po ba kayo gagamit ng chemical para ma extract ang nickel?	Mrs. Jurelac Marquez – Religious Organization	Pag ininit ang nickel ore humihiwalay ito sa lupa. Ang ihahalo ay coal at silica, hindi gagamit ng kahit anong chemical.
	Lahat po ba ng bundok ay bubungklin ninyo	Kap Joseph Bautista	May mga certain area lang po na imimina sakop ng MPSA hindi po buong bundok ng Candelaria.
	Saan parte po ng Candelaria itatayo ang planta	Kap Roel Ijan	Ang planta ay itatayo sa Barangay Malabon
	Pagkatapos ng public scoping, magkakaroon po ba	Kap Julio Echalico	Engr. Carlo Arida - EMB Sa EIA na gagwin ng kumpanya mag iikot po ang

Module	Issues/Concerns	Person who raised the issue	Response from the Proponent/Preparer/EMB
	ng public hearing per barangay? Sapagkat ang mga magsasaka ay dapat na /makuha rin ang opinion patungkol sa proyekto		consultant upung mag sagawa ng FGD at IEC para makuha ang mga agam-agam ng inyong mga nasasakupan. Sa Public Hearing po ipopost po ang Notice sa dyaryo ng dalawang beses, mag popost din po ng tarpaulin sa munisipyo at mga barangay, may mga sulat din po na ipapamigay upang masigurado na lahat ay makaka alam sa aktibidad. Axceltechs Bago po kami mag simula sa aming pag aaral at pag kuha ng samples kami po ay bibisita sa inyong Barangay upang magpa alam o ipa alam ang mga activity na aming gagawin. Magkakaroon din po ng FGD at survey ,upang makuha po naming ang inyong mga sa loobin sa proyekto at ito po ay isasama naming sa gagawin naming pag aaral.
	Mayron bang additional plant para sa pag gawa ng bricks, tiles at roofs.	Kap. Ruben Malay	Itong livelihood natin, bibigyan po natin ang bawat barangay ng makina sa pag gawa ng bricks atbp. Kasama na rito ay ang mixture ng pag gawa ng mga ito. I sundry ito para maging roof at floor tiles.
Lupa	Ang barangay namin ay sagana sa agricultura at pangingisda. Ang lugar po namin ay pinaka mababang Barangay sa Candelaria. Sana po ay tuparin ninyo ang mga environmental mitigation na ipinangako ninyo.	Kap Joseph Bautista	Parte po ng gagawin ng consultan ang pag aaral sa Lupa, hangin, tubig, at tao kung pa ano po ma poprotektahan o ma iiwasan ang impact ng proyekto.

Module	Issues/Concerns	Person who raised the issue	Response from the Proponent/Preparer/EMB
	Pano maprevent ang soil erosion pag may bagyo sa mining area.	Kap Gil Ednave	Limited lang po tayo sa 100hectares na mining block hanggat ma aari hindi tayo lalagpas sa 100 upang hindi mag dulot ng pag guho ng lupa. Mag kakaroon din ng slope protection program upang mapalakas ang kapit ng lupa.
	Ang Zambales hindi po mataas ang nutients ng lupa kaya hindi po feasible talga ang pagsasaka. Sana po ay ma impluwensyahan nyo ang iba pang investor para mag tayo ng proyekto dito sa Zambales upang mas mapaunlad pa ang probinsya. Sana po ang mga mining company ay mag isip ng proyekto na makikinabanbg ang lahat ng mamamayan tulad ng malinis natubig. Sana rin po ay mag patayo na rin ng steel mill upang hindi na lumabas ng probinsya o bansa ang mga nickel pellets.	Mr. Ebalo Wakon	Marami po Salamat sa buong pusong pas suporta sa proyekto.
	May mga minahan na nag sabi na sa amin na pagkatapos mabuksan o ma mina ng isang lugar ay irerehabilitate agad ang area. Pero base sa experience naming hindi ganun anzg nangyari dahil hanggang ngayon ay nakabukas. Sana po sa inyong operasyon ay mapatupad ninyo ang tamang pag rehabilitate ng mined out areas. Isa pa pong concern ay, yung mapupuno po bang lugar ay miminahin parin o iiwasan nyo nlang po, nagkaroon po kasi dati ng pag uusap na hindi na	For. Cezar Estrada DENR Zambales	Hanggat ma aari ay iiwasan ng kumpanya na mamina o magalaw ang area na mapuno. Parte po ng requirement ng gobyerno ang pag prepare ng Environmental Protection and Enhancement Program na nag lalayon na ma rehabilitate ang area kasabay ng pag mimina. May inilalaang budget ang kumpanya para sa activity na ito at ang mga accomplishment ay minomonitor ng Mine Rehabilitation Fund Committee.

Module	Issues/Concerns	Person who raised the issue	Response from the Proponent/Preparer/EMB
	papayagan minahin ang mga area na may malalaking puno.		
Tubig	Yung wastewater po saan dadaloy?	Mayor Napoleon E. Edquid	Construction of drainage system and series of settling ponds. The cleared water will be utilized as irrigation system for the rehabilitation/revegetation area.
	Meron po ba kayong mitigation plan dahil kami po ay nakatira malapit sa ilog at pa iba iba na ang panahon. Ang volume ng tubig na dumadaloy galing bundok ay marami, ka akibat noon ay ang pag sama ng lupa na galing sa pag mimina, ang pangamba ko po ay mag baha sa aming lugar at matabunun o malunod kami at ang mga sakahan.	Mrs. Jurelac Marquez – Religious Organization	Construction of proper drainage system to be connected in the settling ponds.
	Sana po hindi ma apektuha ang Uacon Lake upang mas mapalago ang Turismo ng Candelaria.	Mac Eay Sanguniang Bayan Member	Sa Mandato ng EMB – mapag aaralan lahat ng aspeto ng Environment (Lupa, hangin, tao, at tubig). At tulad po ng aming na banggit mag kakaroon po ng settling ponds at drainage system.
	Gaano kalaki ang settling pond na itatayo ng kompanya	Kap Gil Ednave	Ang settling pond ay idedesenyo batay sa 100 years na pinakamalakas na bagyo upang masiguro na hindi ito aapaw.
Tao	Kung halimbawa po na matutuloy ang planta sa Candelaria ano po ang magandang makukuha ng aming barangay.	Kap Ricky Eclarino (Brgy. Lauis)	Magkakaroon ng pangangailangan ng empleyado. Housing project mula sa waste ng planta (slags).

Module	Issues/Concerns	Person who raised the issue	Response from the Proponent/Preparer/EMB
	Sana po ay turuan din bawat Barangay sapag gawa ng tiles, bricks atbp.	Kap. Ruben Malay	Bawat Barangay po ay magkakaroon ng pag sasanay.
	Alam ko naman na bawat impact ay meron kayong mga mitigating measures. Ang concern ko ay para sa mga Barangay, sa mga mining company sa mga host Barangay ay meron SDMP upang magamit namin sap ag tulong sa mga kabarnagy namin. Sana naman may certain portion ang mga Barangay sa SDMP ng Munisipyo.	Kap. Imelda Dominguez ABC President	Axceltechs Ito po ay 1.5% ng operating cost. Pwede po natin magamit ang SDMP sa training ng bawat Barangay sa pag gawa ng bricks at tiles. Ang mga programa po sa SDMP ay ma identify base sa pangangailangan ng bawat Barangay na sakop ng proyekto.

A perception survey for the direct impact barangay was conducted last May 28 – June 1, 2018.

V. Summary of Alternatives Considered

Summary of alternatives considered:

Location	There is no project location alternative considered in the project since the mining area/blocking will be based on the location of available resource within the MPSA.
Mining Method	Considering the type and location of mineral to be extracted, the only feasible mining method for the project is surface mining method, thus, there were no other alternative method considered for the project.
Technology	The common nickel processing plant being use by the industry is the High-Pressure Acid Leach (HPAL) method. The HPAL process utilizes elevated temperatures (roughly 255 degrees Celsius), elevated pressures (roughly 50 bar or 725 psi), and sulfuric acid to separate nickel to the laterite ore.

C. SUMMARY OF BASELINE CHARACTERIZATION

Module	Summary of Baseline Conditions
Pedology	Soils of the area are mixtures of fragmented and partly or wholly weathered rock and minerals, organic matter, water, and air, in greatly varying proportions, and have more or less distinct layers or horizons developed under the influence of climate action of the different factors of soil formation acting upon the parent material that have continued through ages.
Terrestrial	A total of 113 species belonging to 47 families were observed in the study area. All other plant species that can be observed inside the area but not covered by the plots were also included in the assessment for the general species composition but not in the specific computations for diversity indices and dominance in specific plots. -A total of eight species of amphibians and reptiles have been noted where four (4) are frogs, two (2) snakes, and two (2) lizards. - A total of nine (9) species of volant and non-volant mammals were noted through mist netting, trapping, opportunistic sampling and ethnobiological accounts. There were four species from two families (Hipposideridae and Pteropodidae) of volant mammals (bats) observed. -A total of 40 species belonging to 28 taxonomic families of birds were observed through transect walks, mist netting and ethno-biological accounts. One of the notable species that was observed include the endemic Philippine Duck (*Anas luzonica*) which has been categorized as Vulnerable by the International Union for the Conservation of Nature (IUCN) and DENR Administrative Order (DAO) 2004-15. According to IUCN, Vulnerable species are likely to become endangered unless the circumstances that are threatening its survival and reproduction improve.
Hydrology	Based on the NAMRIA topographic map, surface water bodies that may be impacted by the Project include Agnacon River, San Vicente River, Lauis River, and the coastal area of Candelaria where outlets of these rivers are located (*Figure 63*). Lauis River is one of the Principal Rivers of Central Luzon Water Resources Region with a drainage area covering about 406 km^2 or 40,600 ha. Drainage areas of Agnacon River and San Vicente River are 7,541 ha and 3,595 ha, respectively. Determining the characteristics of watershed (i.e. area, topography, land use, etc.) and the area of the project relative to the watersheds covering the project area would be helpful in assessing the project impacts on hydrology and water quality. The quality and quantity of water passing

Module	Summary of Baseline Conditions
	through a certain reference point or outlet of a watershed is highly dependent on the watershed characteristics and on the activities within that watershed.
Water Quality	Exceedances were observed for the Fecal Coliform count in stations P2-E and P7-C during the dry season sampling and in stations P2-D, P2-F, P2-G, P7-B, P8-A and P8-C during the wet season sampling. Comparing the results for the dry and wet season sampling, significant increase in Fecal Coliform count can be observed for stations P8-A (17 MPN/100ml to 920,000 MPN/100ml) and P8-C (79 MPN/100ml to 35,000 MPN/100ml).
Marine Ecology	-Remaining corals in the primary and secondary impact area of the proposed mining project are few and dispersed and the coral colonies inside the marine protected areas are the last coral ecological niche in the municipal waters. Thus the corals in the two MPAs need to be protected and recruitment needs to be enhanced. - In spite of the incessant sediment intrusion at the present time, the quality of the seawater in the project's coastal impact area remains viable for coral and fish population replenishment and the migration of fish towards the reef flats. - The local fisheries sector is currently beset with declining yields and looming long term unprofitability and loss of incomes from small-scale fishing. - The variability of macrobenthic organisms are generally affected by abiotic factors such as substrate types, salinity, water temperature, and dissolved oxygen. Biotic factors like recruitment, predation, and natural mortality could also affect the changes in macrobenthic community. Other disturbance on the habitat in either anthropogenic or natural in origin, like water pollution and displacement of bottom sediments that may cause severe depletion on their population.

D. EIA Summary

Summary of Environmental Impact

Identified Impact	Mitigating Measure
Major - Long Term Impact	
Water	
Degradation of marine water quality	• Regular (at least monthly) ocular inspection of wastewater systems/pollution control facilities • Maintenance and desilting of oil and grease traps and silt ponds as needed; • Implementation of existing Emergency Preparedness and Response for Oil Spills; • Provision of secondary containment
Water use competition	• To improve groundwater recharge, the vegetation at the hilly portions bordering the Plant at the east side must be maintained or enhanced through forest protection, reforestation or enhancement planting.
Air	
Air pollution (criteria pollutants and trace metals) from kiln operations	• Proper operation of the ESP • Installation, proper operation, and maintenance of the CEMS • Proper monitoring at the off-site ambient air quality monitors • Conduct validation air dispersion modelling
Air pollution (SOx, NOx, CO, and particulates) from other process sources	• Regular compacting of unpaved access roads • Proper operation and maintenance of air pollution control devices • Formulation and implementation of a motor vehicle maintenance program, including emissions testing • Proper monitoring at the off-site ambient air quality monitors
Contribution to climate change from greenhouse gas emissions	• Implement and maintain a GHG inventory program • Formulation and implementation of a greening program

Identified Impact	Mitigating Measure
Noise	
Noise pollution	• Incorporation of noise criteria in the specifications and selection of equipment • Use of effective noise-attenuating materials for the plant structure and walling • Planting of the appropriate vegetation as buffer
People	
Threat to public health and safety • Health effects due to dust inhalation • Exposure to other health and safety hazards associated with WestChinaMin activities	• Conduct of regular maintenance of plant equipment specifically the installed pollution control devices • Conduct routine monitoring to assess effectiveness of installed pollution control devices • Formation of Team that will serve as Complaint Desk to address Pollution- and Safety and Health- related concerns of the community • Effective implementation of Environmental Management Program and Safety and Health Program
• Disturbance on the peace and order of the area because of influx of workers and economic activities	• Provide assistance and coordination with the Barangay Council, Barangay Peace and Security Officers (BPSO), as well as the Local Police.
• Generation of Local Benefits from the Proposed Project • Increase in income-earning opportunities will increase spending potential, providing opportunities to increase the demand and supply of goods and services indirectly increasing the overall wealth of the area • Introduction of new economic activities and establishment of new businesses will increase revenue collection of the LGUs from taxes and fees	• Coordination with the Barangay and Municipal LGUs to ensure proper zoning of business area, peace and order, sanitation, and solid waste management • Westchinamin Corp to ensure the payment of taxes and fees of their suppliers and service providers. This may be included as part of evaluation criteria for contact renewal • Offer training opportunities for business and livelihood development and management

Identified Impact	Mitigating Measure
Major Short Term Impact	
Air	
Air pollution from fugitive dust during ground clearing operations and structure erection.	• Dust suppression in active construction areas • Compacting of exposed soil • Provision of tarpaulin cover on trucks transporting construction materials • Immediate hauling of spoils • Impose speed restrictions
Noise	
Noise from construction activities	• Regular maintenance of motor vehicle • Provision of barriers and shielding stationary vibrating equipment • Proper scheduling of noisy activities during day time
People	
• In-migration and increase in day-time population may compete with the locals in terms of employment, project benefits, natural resources, local health, welfare services and infrastructure • In migration may also lead to proliferation of informal settlers for temporary abode during construction phase • Immigrant workers may also introduce lifestyles and behaviors different from the locals which may lead to social tensions	• Priority hiring of unskilled and semi-skilled workers from the local communities in construction and expansion works ; • Require and monitor contractors' commitment on providing local employment; • Implementation of skills development program to ensure support to local population in obtaining employment opportunities; • Proper induction of workers and haulers to prevent occurrence of peace and order problems or security breaches;

1.0 PROJECT DESCRIPTION

1.1 Project History

The history of the mining claims are as follows:

a. On February 10, 2010, Mineral Production Sharing Agreement (MPSA) No. 316-2010-III was approved by the then DENR Acting Secretary ELEAZAR P. QUINTO in favor of MR. RAMON G. PERLAS with a contract area of 286.2531 hectares. The MPSA had a term of twenty-five (25) years or up to February 9, 2042.

b. MR. RAMON G. PERLAS subsequently executed a "Deed of Assignment and Transfer of Rights of MPSA No. 316-2010-III" in favor of WESTCHINAMIN CORPORATION on April 1, 2015. An Addendum to said Deed of Assignment and Transfer of Rights was also executed by the Heirs of MR. RAMON G. PERLAS and WESTCHINAMIN CORPORATION on November 20, 2015.
c. On February 2, 2016 the Deed of Assignment and Transfer of Rights of MPSA No. 316-2010-III including the Addendum was approved by then MGB Director LEO L. JASARENO by authority of the DENR Secretary.
d. WESTCHINAMIN then acquired various Applications for Mineral Production Sharing Agreements/Exploration Permit Applications as follows:

Table 1 - Various Deeds of Assignment and Transfer of Rights

No.	Previous Applicant	Application No.	Location	Area (hectares)	Date Acquired	Date Approved by DENR/MGB
1.	Neutron Construction & Marketing Corp.	MA-P-III-09-00 (APSA-000318-III)	Lucapon, Sta. Cruz, Zambales	863.1159	March 10,2016	April 25,2016
					April 12,2016 (Addendum)	April 25,2016
2	Gary Gatlabayan	AEP-III-19-089 (EXPA-000-127-III)	Masinloc, Zambales	1,397.2010	March 19,2016	April 25,2016

No.	Previous Applicant	Application No.	Location	Area (hectares)	Date Acquired	Date Approved by DENR/MGB
					April 12,2016 (Addendum)	April 25,2016
3	Herrador Mining Corporation	AEP-III-11-013 (EXPA-000188-III)	Botolan, Zambales	2,226.0687	March 29,2016	April 25,2016
					April 12,2016 (Addendum)	April 25,2016
4	Citygroup Philippines Corporation	MA-P-III-15-969 (APSA-000-165-III)	Candelaria, Zambales	1,134.0000	August 4,2015	April 25,2016
					April 19,2006 (Addendum)	April 25,2016
5	Karangalan Resources and Mining Corporation	AEP-III-12-059 (EXPA-0000-46-III)	Candelaria, Zambales	1,620.0000	November 26,2015	April 25,2016
					April 12,2016	April 25,2016
6	Radiant 3100, Inc.	AEP-III-27-079 (EXPA-000099-III)	Masinloc, Zambales	1,813.0000	March 19,2016	April 25,2016
					April 12,2016 (Addendum)	April 25,2016
7	Gina Gatlabayan	AEP-III-07-089 (EXPA-000-115-III)	Candelaria, Zambales	989.0549	March 19,2016	April 25,2016

No.	Previous Applicant	Application No.	Location	Area (hectares)	Date Acquired	Date Approved by DENR/MGB
					April 19,2016	April 25,2016
	Total			**10,042.4405**		

e. On May 23,2016, the MGB approved the expansion of the contract area of MPSA-316-2010-III by annexing as Parcels II, III, IV, V, VI and VII the proposed contract areas of the Exploration Permit Applications acquired by Westchinamin Corporation and redenominating MPSA-316-2010-III as MPSA-316-2010-III, Amended I.
f. On June 22, 2016, the MGB approved the Partial Declaration of Mining Project Feasibility of Westchinamin Corporation covering 286.2531 hectares located in Sta. Cruz, Zambales.
g. On June 29,2016, the MGB approved the amendment of MPSA-316-2010-III, Amended I with the following contract areas:

Table 2 - MPSA-316-2010-III, Amended I

Parcel No.	Location	Area(hectares)
I	Sta. Cruz, Zambales	286.2500
II	Candelaria, Zambales	1,483.3508
III	Masinloc, Zambales	659.4907
IV, V, VI	Palauig, Iba and Botolan, Zambales	1,484.7208
VII	Candelaria, Zambales	164.7884
VIII	Candelaria, Zambales	82.4208
		4,161.0215

h. The company was issued a separate Environmental Compliance Certificate (ECC) for Parcel I under MPSA No. 316-2010-III, Amended I covering 286.253 ha..

1.2 <u>*Project Location and Area*</u>

The proposed three (3) Parcels of MPSA No. 316-2010-III, Amended I where the Project is located are within the Barangay of Uacon, Malimanga, Taposo, Yamot, Sibacan, Malabon at Pinagrealan, Minicipality of Candelaria and Barangay Guinabon Minicipality of Sta. Cruz both in the Province of Zambales. It is bounded on the North by Neutron Mining, on the South by Zambales Diversified Mining Corp. on the East by Eramen Minerals, Inc., and on the West by Barangay Lucapon South, with the following geographical coordinates stated below.

Parcel I

Corner	Latitude	Longitude
1	15°47’45.20”	120°02’51.40”
2	15°47’54.30”	120°02’51.40”
3	15°47’54.30”	120°02’41.50”
4	15°48’09.80’	120°02’41.50”
5	15°48’09.80”	120°02’30.00”
6	15°49’00.00”	120°02’30.00”
7	15°49’00.00”	120°03’00.00”
8	15°48’30.00”	120°03’00.00”
9	15°48’30.00”	120°03’30.00”
10	15°47’55.10”	120°03’30.00”
11	15°47’55.10”	120°03’21.00”
12	15°47’45.20”	120°03’21.30”
Parcel I Area = 286.2531hectares		

Parcel II

Corner	Latitude	Longitude
1	15°37’00.00”	119°58’30.00”
2	15°38’00.00”	119°58’30.00”
3	15°38’00.00”	119°58’00.00”
4	15°39’30.00”	119°58’00.00”
5	15°39’30.00”	120°00’00.00”
6	15°37’00.00”	120°00’00.00”
Parcel II Area = 1,483.3508 hectares		

Parcel VII

Corner	Latitude	Longitude
1	15°40’00.00”	119°58’00.00”
2	15°41’00.00”	119°58’00.00”
3	15°41’00.00”	119°58’30.00”
4	15°40’00.00”	119°58’30.00”

Corner	Latitude	Longitude
Parcel VIII Area = 164.7884 hectares		

Parcel VIII

Corner	Latitude	Longitude
1	15°36’00.00”	119°59’30.00”
2	15°36’30.00”	119°59’30.00”
3	15°36’30.00”	120°00’00.00”
4	15°36’00.00”	120°00’00.00”
Parcel VIII Area = 82.4208 hectares		

1.2.1 Accessibility

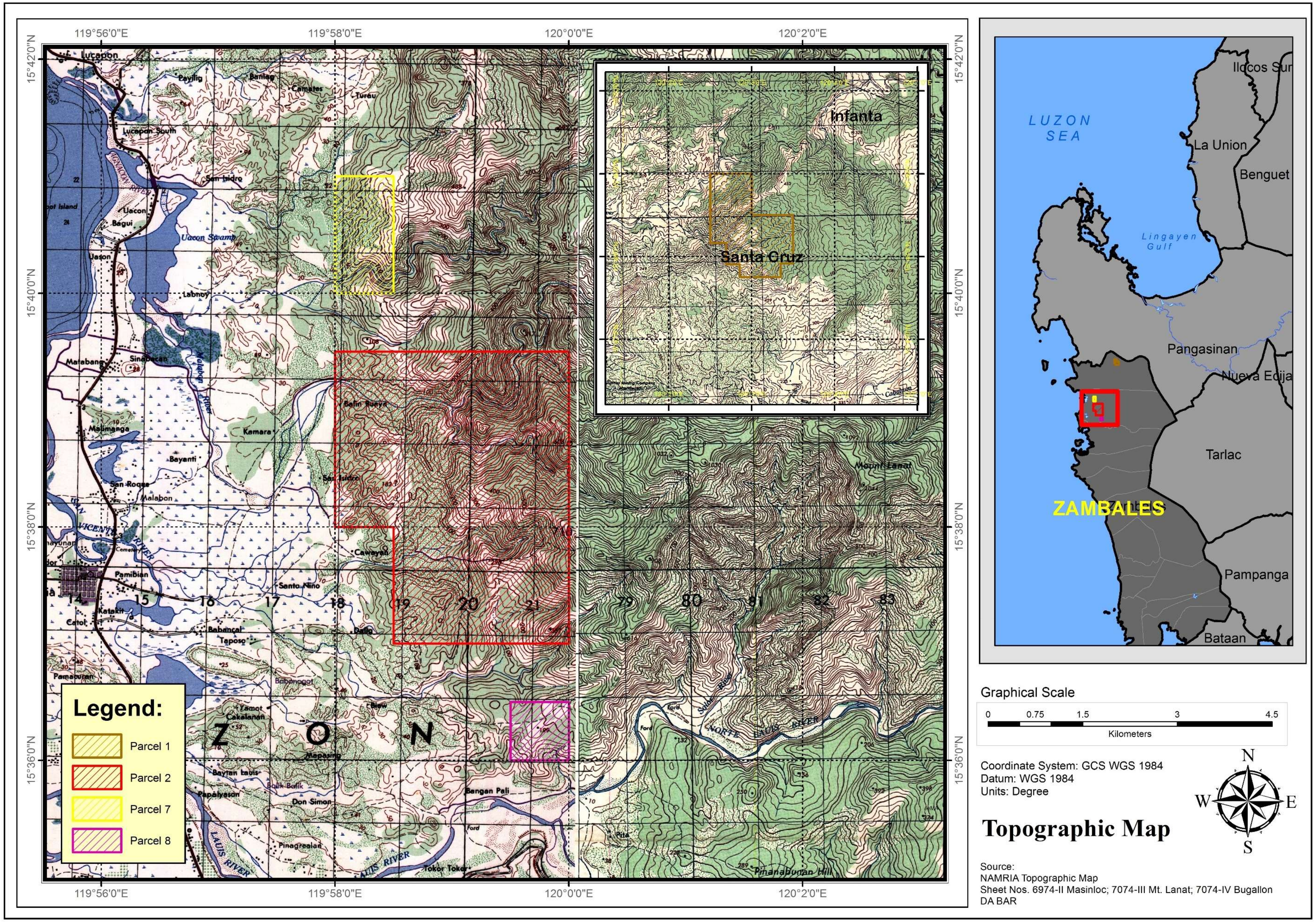
Candelaria, Zambales is about two hundred seventy four (274) kilometers north of Manila and sixty four(64) kilometers north of Iba, the capitol town of Zambales. It is the second most northernly town of Zambales and is bounded on the north by Sta. Cruz, on the south by Masinloc, on the east by the Province of Pangasinan and by the West Philippine Sea on the west. The town can be reached from Manila via the Olongapo-Gapan Road of the Subic-Clark-Tarlac Expressway (SCTEX) up to the Subic Bay Metropolitan Authority (SBMA) then through the Zambales-Pangasinan National Highway with a travel time of about six (6) hours by motor vehicle. From the north, it can be accessed through the Western Pangasinan National Highway.

1.2.2 Impact Areas

The area subjected to the EIA was based on the perceived direct and indirect impact areas of the proposed project. As stipulated in DAO No. 2003-30, direct impact areas, in terms of physical environment, are those where all project facilities are to be constructed/situated and the designated project area. The entire area within the Parcels being applied for ECC are all considered direct impact areas. The direct impact barangay are Barangays of Uacon, Malimanga, Taposo, San Roque, Sibacan, Lauis, Malabon and Pinagrealan all within the Municipality of Candelaria and Barangay Guinabon, Municipality of Sta. Cruz.

On the other hand, areas not directly subjected to any activities/construction and those outside the project area but are within the jurisdiction of the Municipality of Candelaria and Sta. Cruz (e.g. stretch of the river draining the project area, communities along haul roads) are considered as indirect impact areas. A map showing the direct impact areas are shown in *Figure 4.*

Figure 1- Location Map



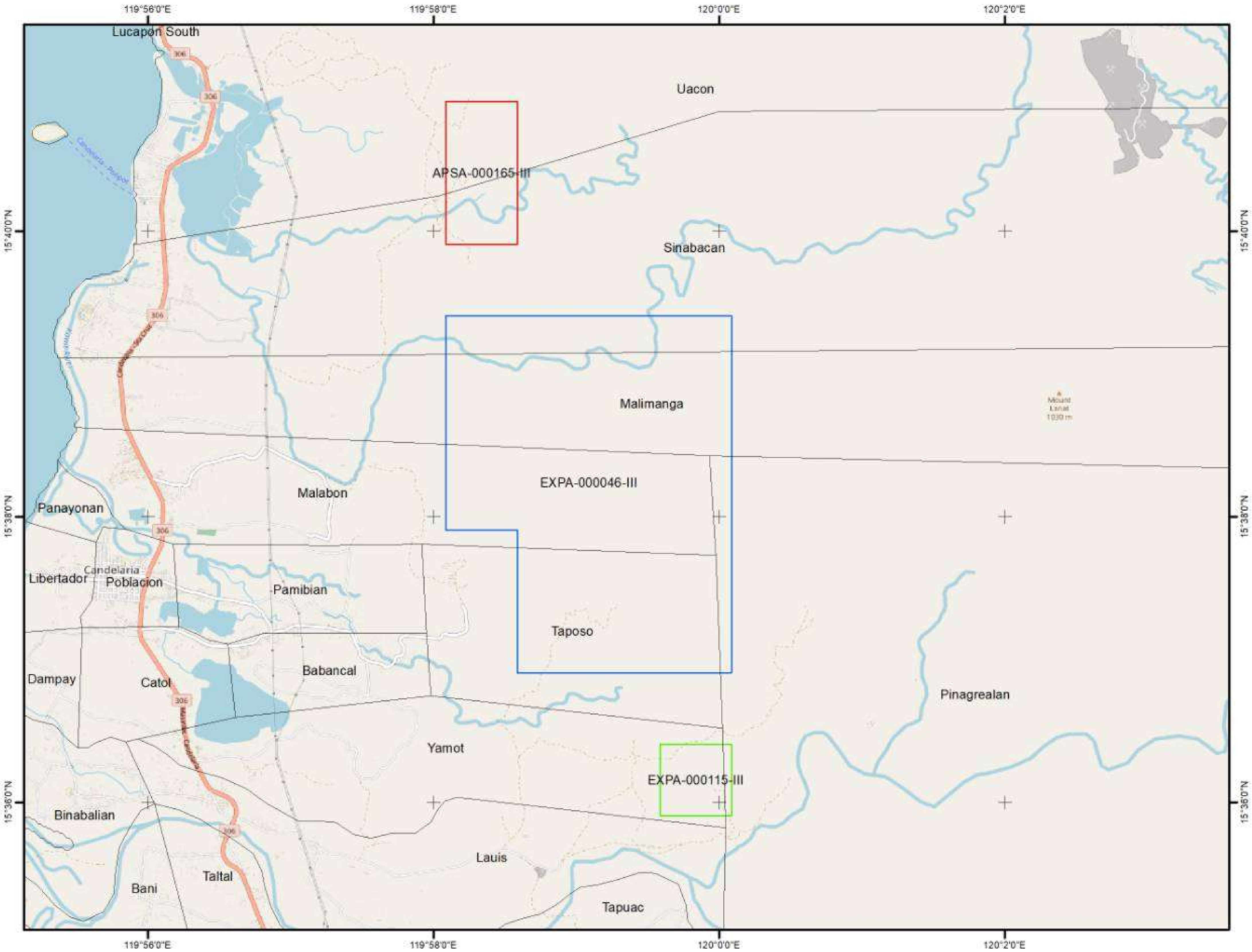


Figure 2 - Barangay Boundaries (proosed expansion)

Figure 3- DENR Approved Sketch Map of MPSA No. 316-2010-III, Amended I

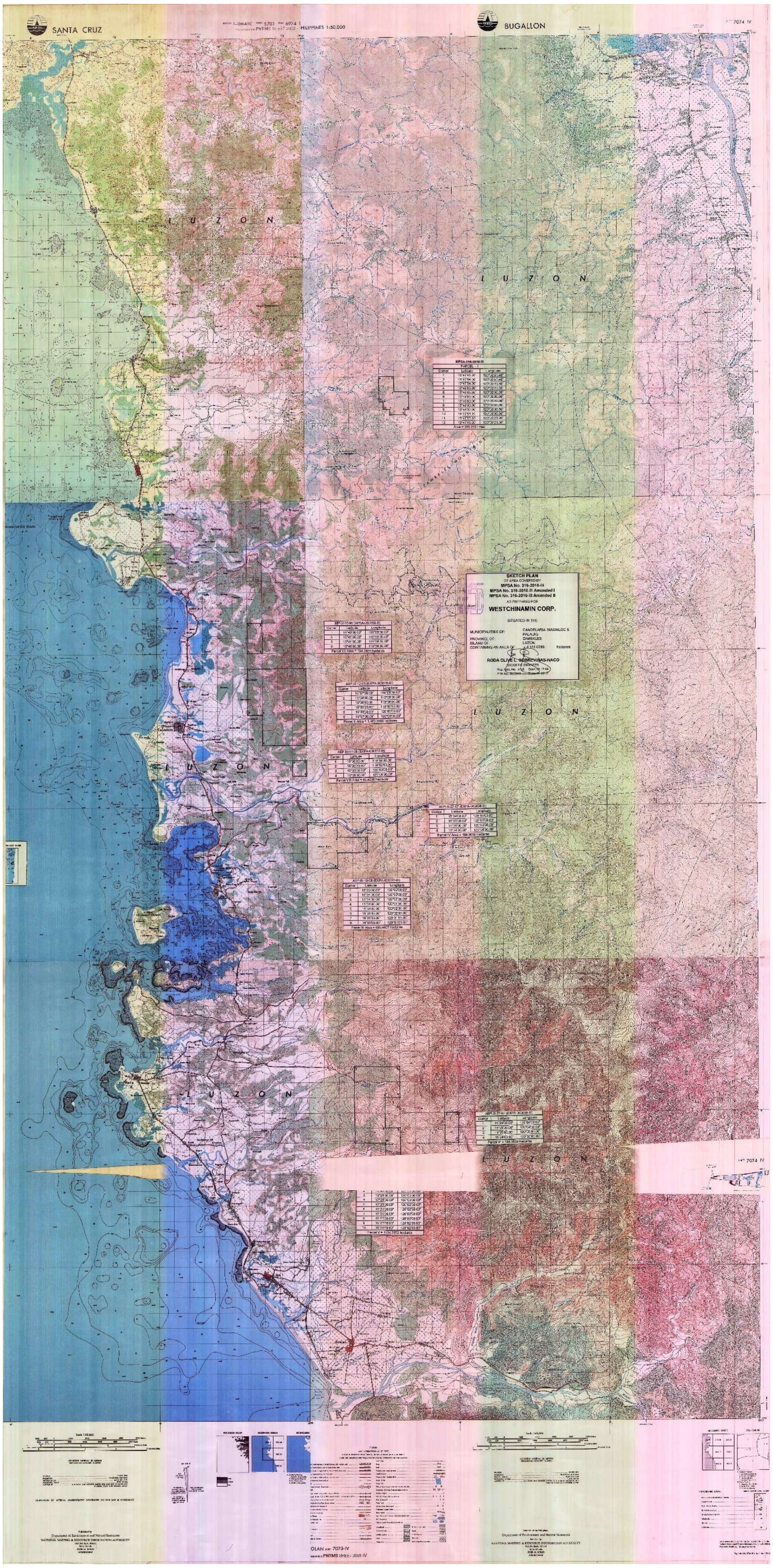
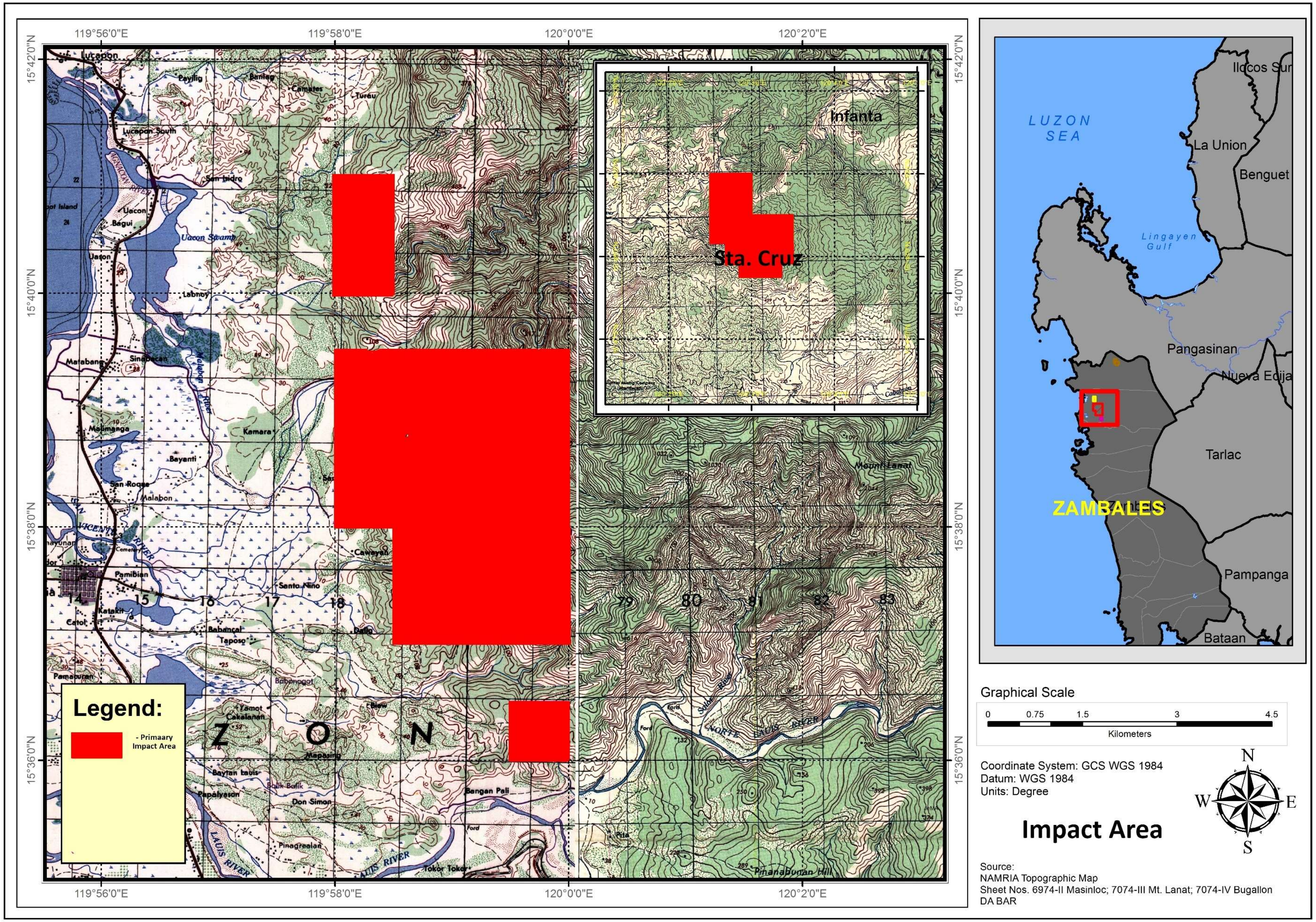


Figure 4 - Direct Impact Areas of the Project



1.3 Project Rationale[1]

The project will contribute to the national economy by way of generating direct employment to 508 people with an annual payroll of PhP 285,724,050 excluding bonuses and other fringe benefits. Providing employment government revenues in the form of excise and income taxes amounting to the following:

Table 3 - Excise and Income Taxes

Taxes	Per Year	Total, 14 Years
Excise Tax	42,129,742	589,816,381
Income Tax	960,343,804	13,444,813,262
Sub-Total	1,002,473,546	14,034,629,644

- Increasing local taxes and licenses by PhP 54,342,114 per year, on the average or a total of PhP760,789,596 over a 14-year period.
- Allotment of Social Development expenditures amounting to PhP197,365,904 annual average or PhP2,763,122,656 over a 14-year period.
- Developing business enterprises
- Extending much needed assistance to the immediate community in terms of health, training, livelihood programs, education and technology
- Generating foreign exchange revenues of US$ 2,915,237,338 over a 14-year period
- This project is vital and would be a major contributor to the national economy.
- to service contractors, sub-contractors and service providers
- Increasing national

1.4 Project Alternative

1.4.1 Mining

The Project components are located inside the mining tenements issued by the Philippine Government. Issuance of MPSAs over these areas indicates that these are mineralized lands as validated by the Final Exploration Report over these areas. As such, currently, there are no known possible project alternatives for the area.

[1] PARTIAL MINING PROJECT FEASIBILITY STUDY, Engr. Graciano M. Calanog, Jr. 2018

Further, considering the type and location of mineral to be extracted, the only feasible mining method for the project is surface mining method, thus, there were no other alternative method considered for the project.

1.4.2 Processing Plant

The common nickel processing plant being use by the industry is the High-Pressure Acid Leach (HPAL) method. The HPAL process utilizes elevated temperatures (roughly 255 degrees Celsius), elevated pressures (roughly 50 bar or 725 psi), and sulfuric acid to separate nickel to the laterite ore. However, there are some challenges to be considered in this process:

- Patented Technology by Sumitomo
- Corrosion and Erosion
- Highly Acidic Process
- Energy Requirements
- Location, larger project footprint and treatment of spent ore

On the otherhand, low-temperature reduction process will utilized coal as a reducing agent, therefore, coke or petroleum will not be used as a reducing agent. Under low temperature, it will be very difficult to generate NOx, SOx and other harmful gases, and therefore emissions will be well below the melting furnace emission. At low temperature, the amount of cooling water will also be used significantly less than the amount of the melting furnace. The process will significantly reduce energy consumption of laterite ore smelting. With the new technology, it only requires 1,080 Kg of standard coal to produce one ton of nickel alloy with the content of Ni10%.

1.4.3 Resource Utilization

The project will source its power requirements to National Grid Corporation, in the event of power shortage/interruption the solar power plant and stand-by generator sets will be utilized.

1.5 PROJECT COMPONENTS

The Project Site Development Plan is shown in *Figure 8* and *Figure 9.*

1.5.1 Mining

The company is proposing to mine nickel laterite within three (4) parcel within the area of MPSA 316-2010-III, Amended I. Each mining area will have the following component:

a) Stockyard Area
b) Over burden or waste dumps
c) Settling Ponds and Erosion Control Facilities

Mining will use excavators to extract the ore and load to dump trucks for hauling to the processing plant stockpile area. Generally, an area to be mined will be developed based on the contour/topography of the whole area by terracing or benching. During mining, all overburden materials and boulders identified will be set aside. Once the area is mined out, progressive rehabilitation will be implemented.

During every stage of the mining operations, safety measures will be adopted as required in the Mines Safety provisions of DAO 2000-98. Trucks shall be inspected at the beginning of each shift and during service periods. Any defects shall be reported immediately to the supervisor. Gauges shall be in the operating range after start up and these shall be checked often during operation. When travelling on a haulage road at the start of a shift, operators shall be required to drive slowly and check road/s for conditions and for any hazards. The road shall be cleared before the truck is moved. The unit shall not be moved unless warning signal is given. A minimum safe distance of 30 meters with a maximum speed of 30 kilometers per hour shall be observed in following another truck on a downgrade under normal conditions.

1.5.1.1 Stockyard Area and Overburden

The company will maintain an ore stockpile area, topsoil area and wastedump. Topsoil stockpiles will be located in mined-out areas to minimize creating additional disturbed areas. Stockpile slope will be kept at a low angle and height to minimize slumping. The proposed height of the stockpile will depend on the angle-of-repose of the material. This is to ensure that the maximum volume of materials will be stockpiled without sacrificing safety. Angle of repose is the maximum angle of descent or dip of the stockpile slope relative to the horizontal plane.

Stockpiling of the topsoil for prolonged periods may also deteriorate the biological components in the soil deteriorating its quality. Stripping of soil at unsuitable moisture content (i.e. when wet or saturated) may also lead to compaction and loss of soil structure.

1.5.1.2 Settling Pond

Settling ponds will be constructed in series. These ponds shall be appropriately designed to effectively arrest the silt coming from the mining area to meet the required water quality of the recycled water and DAO 35 effluent standards in case of water discharge. Sediments shall be impounded from the first to the third pond in succession. While, the second pond is utilized, the first pond shall be drained and allowed to dry and desilted. Recovered silt materials will be used to backfill mined out areas. The third pond shall act a buffer for the first two ponds and shall be the source of recycled water for the plant.

To minimize the silt load, from the mining areas, siltation traps along the drainage system will be built inside the active areas. Settling ponds will be desilted as the need arises.

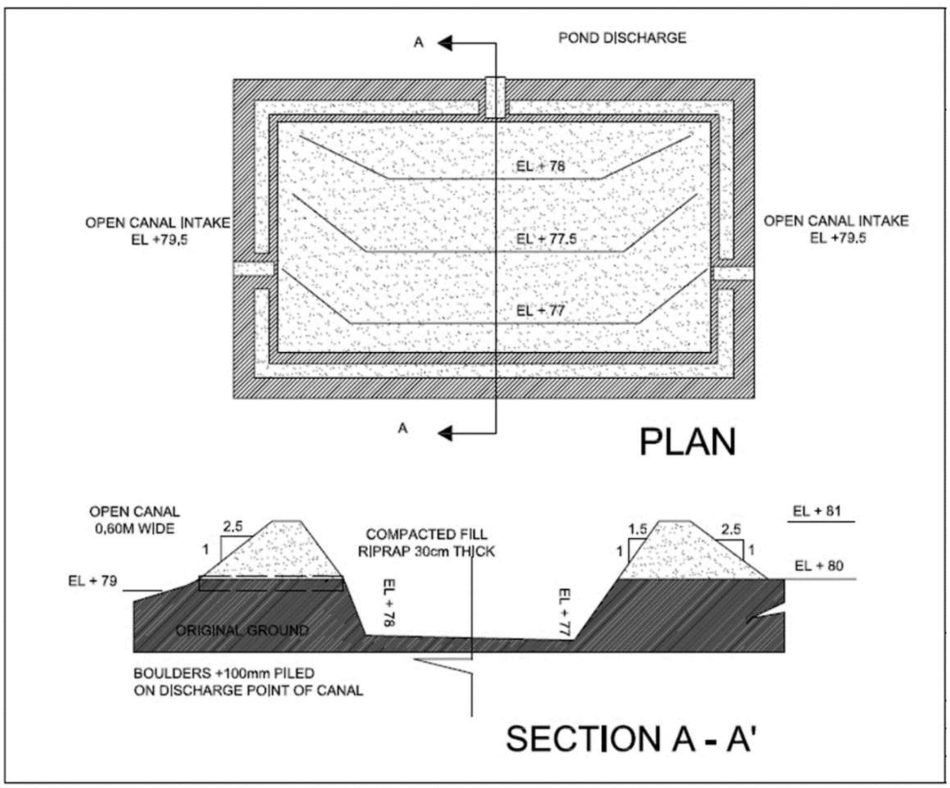


Figure 5 - Settling Pond Design

1.5.2 Ferro-Nickel Processing Plant

Ferro Nickel Microwave Technology Processing Plant which is to be located in Candelaria and will have the following components:

a) Raw Materials Storage (Nickel, Coal, Dolomite and Flux) and Distribution
b) Crushing, Screening and Air/Sun Drying area
c) Material Forming/Mixing
d) Low Temperature Reduction and Grain Growth
e) Pulverized Coal Preparation
f) Slag Stockpile Area

1.5.3 Support Facilities/Infrastructures

Support Infrastructures for both Mining and Processing will have the following components:

1.5.3.1 Access and Mine roads

Mine haul road will be constructed following the topographic surface contour. This shall be ballasted with crushed bedrocks extracted from mining areas. Maximum adverse road gradient is 8.0%. The establishment of such facility will entail clearing and grabbing activities that may possibly cause soil erosion and water contamination.

1.5.3.2 Solar Farm for with 48MW Capacity

A 48MW Solar Farm will be established to support the power requierememt of the processing plant.

Table 4 - Solar Radiation Data in Candelaria Zambales

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m2/day)													
Lat -15.6 Lon120.1	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
22-year Average	4.65	5.21	5.91	6.20	5.51	5.04	4.67	4.08	4.41	4.58	4.45	4.30	4.92

Figure 6 - Solar Farm Concept

1.5.3.3 Other Facilities

- Assay Laboratory - housed the equipment in assaying the different grade of the ore
- Core house- stockpile for core samples
- Staff House – living quarters of some personnel
- Guest House – receiving quarters for guest
- Environment and Community Development Office
- Mine Engineering Office
- Motor pool – to be used for maintenance of vehicles and equipment.
- Gen Set 30 MW
- Nursery - This will be for plants propagation to be used for rehabilitation

1.5.3.3.1 Equipment

Table 5 and *Table 6* show the equipment requirements for mine and mill operation.

Table 5 - Mining Equipment

Equipment	Number of Unit
Stripping Equipment	
Hydraulic Excavators, 268 Hp, 1.7 cubic meters	1
Dump Trucks, 17 MT	23
Dozers, 310 Hp	1
Payloader, 170 Hp, 4.20 cubic meters	1
Compactor/Roller, 12 T, smooth drum	1
Motor Grader, 140 Hp	1
Lube Truck, 4 x 2	1
Fuel Truck, 4 x 2	1
Water Truck, 4 x 2	1

Equipment	Number of Unit
Flatbed Truck, 12 T with 5T crane	1
Sub-Total	33
Mining Equipment	
Hydraulic Excavators, 268 Hp, 1.7 cubic meters	3
Dump Trucks, 17 MT	50
Dozers, 310 Hp	1
Payloader, 170 Hp, 4.20 cubic meters	1
Compactor/Roller, 12 T, smooth drum	1
Motor Grader, 140 Hp	1
Lube Truck, 4 x 2	1
Fuel Truck, 4 x 2	1
Water Truck, 4 x 2	1
Flatbed Truck, 12 T with 5T crane	1
Sub-Total	62
Road Maintenance Equipment	
Hydraulic Excavators, 268 Hp, 1.7 cubic meters	1
Dump Trucks, 17 MT	1
Dozers, 310 Hp	1
Payloader, 170 Hp, 4.20 cubic meters	1
Compactor/Roller, 12 T, smooth drum	1
Motor Grader, 140 Hp	1
Water Truck, 4 x 2	1
Sub-Total	7
Total	121

Table 6 - Plant Equipment

Equipment	Number of Unit
Material Storage Tank	1
Material Weighing System, 15 TPH	1
Mixing System	1
Pelletizing System	1
Low Temperature Reaction System	1
Grain Growth Reactor	1
Iron Slag Cooling System	1
Hammer Crusher, 22 kW	1
Raymond Mill, 72.50 kW	2
Pulverized Coal and Flux Pretreatment System, 15.00 kW	1
Bi-axial Mixer, 20 TPH, 15 kW	1
High Pressure Ball Machine, 250.00 kW	1
Pre-press, 37.00 kW	1
Belt Machine, 1.50 kW	1
Hydraulic Motors, 2.20 kW	1
Mobile Belt Machine, 3.00 kW	1
Disc Feeder, 3.00 kW	1
Jaw Crusher, 30.00 kW	1

Equipment	Number of Unit
Raymond Mill, 72.50 kW	1
Magnetic Separator, 0.75 kW	1
Packaging Line	1
Loading Equipment	1
Total	23

1.5.3.3.2 Fuel

The project site is located in an area where fuel sources could be made readily available. Diesel fuel, gasoline and lubricants will be sourced from suppliers in Candelaria, Zambales and adjoining cities and municipalities.

Table 7 - Fuel, Oil and Lubricants

	Annual(liters)	*Liters per MT*	*Liters Per Day*
Administrative	46,200	0.015	154

1.5.3.3.3 Water Supply

Water use of the project is estimated as follows:

Table 8 - Project Water Use and Consumption

Component	Water Use, m^3/year	Cubic meters per MT of raw nickel ore [(a)]	Cubic meters per day [(b)]	Water Consumption, m^3/year	Recycled water, m^3/year
Ferro-nickel Smelter	227,400	0.076	758	45,480 (20% make-up water)	181,920 (80%)
Fire Protection [(c)]	10,800	0.004	36	10,800	0
Domestic Consumption [(d)]	16,500	0.006	55	16,500	0
TOTAL	**254,700**	**0.085**	**849**	**72,780**	**181,920**

(a) Annual raw nickel ore production = 3,000,000 MT
(b) 300 days/year
(c) 25 liters per second, 2 hours fire, 5 days/year
(d) Based on the assumption of 110 liters/capita/day x 500 employees

Water use of the Ferro-nickel Processing Plant is mainly for quenching the nickel coming from the Low Temperature Reduction Section (LTRS) that will recover the ferro-nickel alloy through microwave metallurgy. Annual water use of the ferro-nickel smelter is estimated at 227,400 m^3, 80% of which will be recycled back to the processing plant (181,920 m^3). The 227,400 m^3 water is therefore the initial (one-time) water requirement of the Plant needed at start-up (see *Figure 7*). After this, only 20% of the total water use will be withdrawn from the identified water source/s as make-up water resulting to an annual Plant water consumption of 45,480 m^3. Other water uses for the Project include 10,800 m^3/year for fire protection and 16,500 m^3/year for domestic consumption totaling to 254,700 m^3 annual water use and 71,832 m^3 annual water consumption (raw water).

A Water Resource Study shall be conducted by the proponent in order to identify possible sources of water for the Project.

1.5.3.3.4 Power

Power will be sourced through the 48 MW Solar Farm, back-up power will be provided by the National Grid Corporation of the Philippines and emergency generators. Back-up power will be provided by 30 MW emergency generator. Power consumption is estimated at 110.873 kWh/MT or 46 MW.

Table 9 - Power Consumption

	Annual(kWh)	kWh/MT	kWh per day
Ferro-nickel Smelter	329,280,000	109.760	1,097,600
Mine	2,685,600	0.895	8,952
Administrative	384,000	0.128	1,280
Total	332,349,600	111	1,107,832
Total Megawatts	**46**		

1.5.3.3.5 Bituminous Coal

Bituminous coal will be sourced from suppliers in Indonesia and other countries. The process will be required to use 390,000 MT/y of Bituminous Coal to support the proposed operation.

Table 10 - Bituminous Coal Consumption

	Annual(MT)	***MT Coal/MT Ore***	***MT Per Day***
Ferro-nickel Smelter	390,000	0.130	1,300

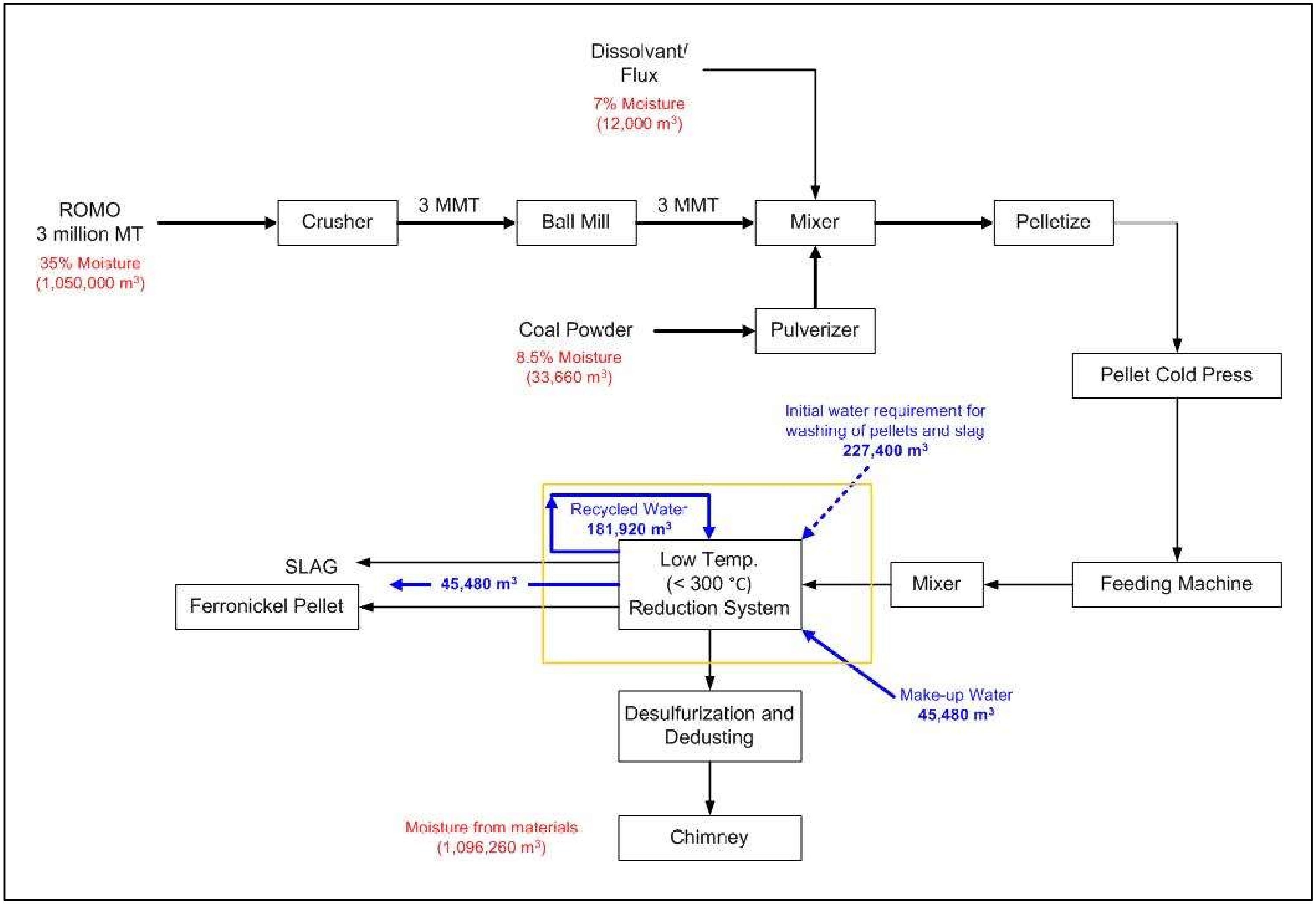


Figure 7 - Water Balance

1.5.4 Pollution Control Devices

Table 11 - Pollution Control Devices and Corresponding Facilities Being Served

Pollution Control Devices	Description	Location
Settling and Siltation Ponds	• Settling ponds will be strategically located within the area of processing. • Siltation ponds will be built within the mining areas to properly address surface run-offs and siltation during construction and operation of the project activities.	To be constructed within the mine site along strategic locations considering various factors such as amount of water runoff, terrain of the area and concentration of mining ores.
Nursery	• Nursery will be established in the project site complete with potting sheds and planting plots for wildlings. • Endemic species will be primarily raised in the nursery. Seeds and wildlings will be collected and raised as planting materials.	Nursery will be established to cater to the needs of the progressive rehabilitation program. This will be located within the plant complex.
Solid Waste Management	• Establishment of Ecological Center, composed of materials recovery facility and composting facility.	Compost will be used in the nursery for rehabilitation program. Segregation of biodegradable and non-biodegradable waste will be practiced. Hazardous wastes are managed based on provisions of RA 6969.
Bag Filter	• 30 cubicmeters per hour, Pulsu Jet (bags abd cages), filter area 440.7 square meter	Primary crusher
	• 40,000 cubic meters, pulse jet(bags and cages) 76.5 cubic meters	Vibrating Screen
	• 5,000 cubic meters per hour, pulse jet(bags and cages) 76.5 cubic meters	Grinding
	• 17,200 cubic meters, pulse jet 192 square meter	Secondary Crusher/Magnetic Separator
Electrostatic Precipitator	• Dust emission 50mg/Ncubic meter, 3,000 square meters	Microwave Furnace

Pollution Control Devices	Description	Location
	filtering area, 99.99% collecting efficiency.	

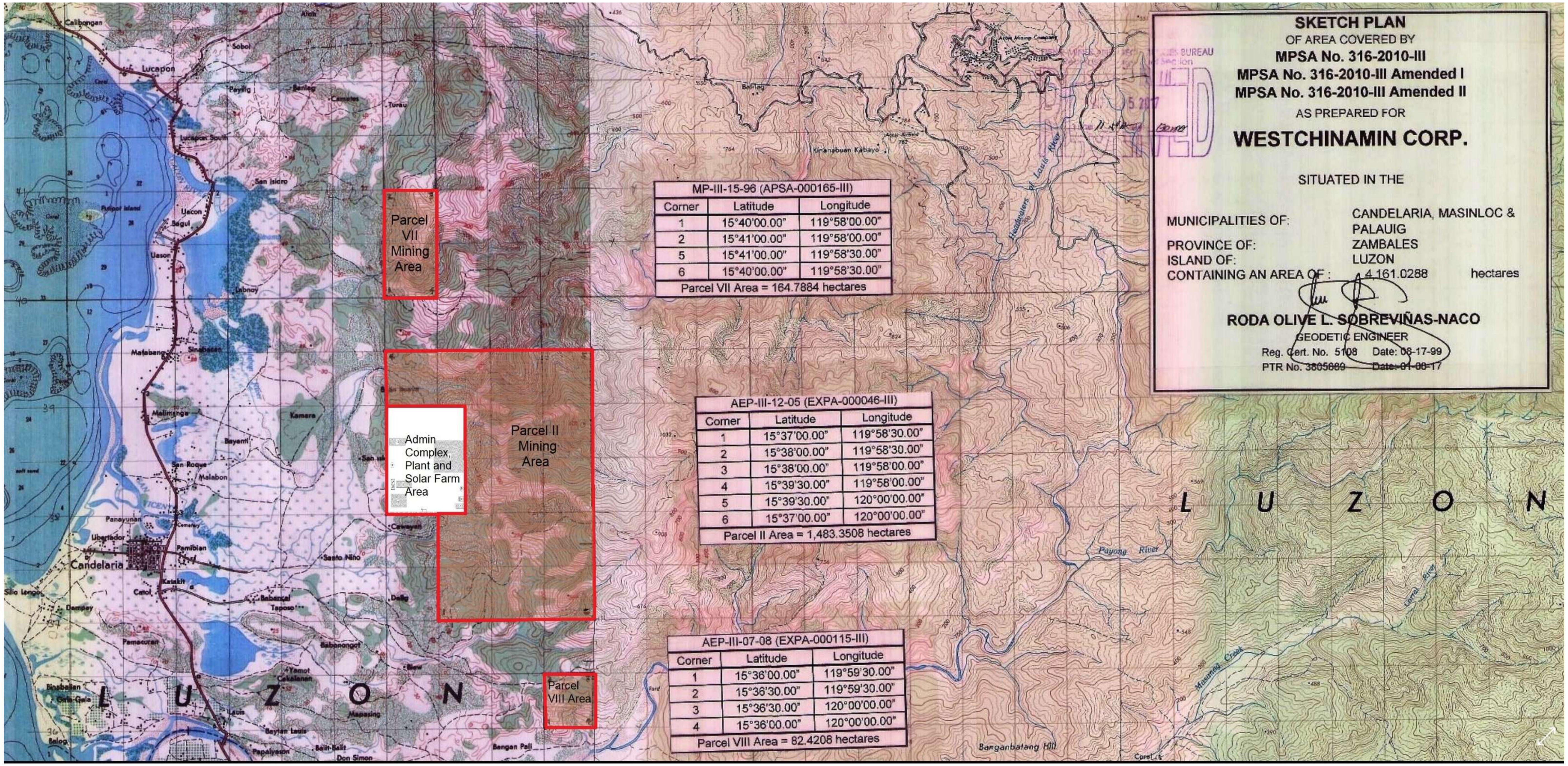
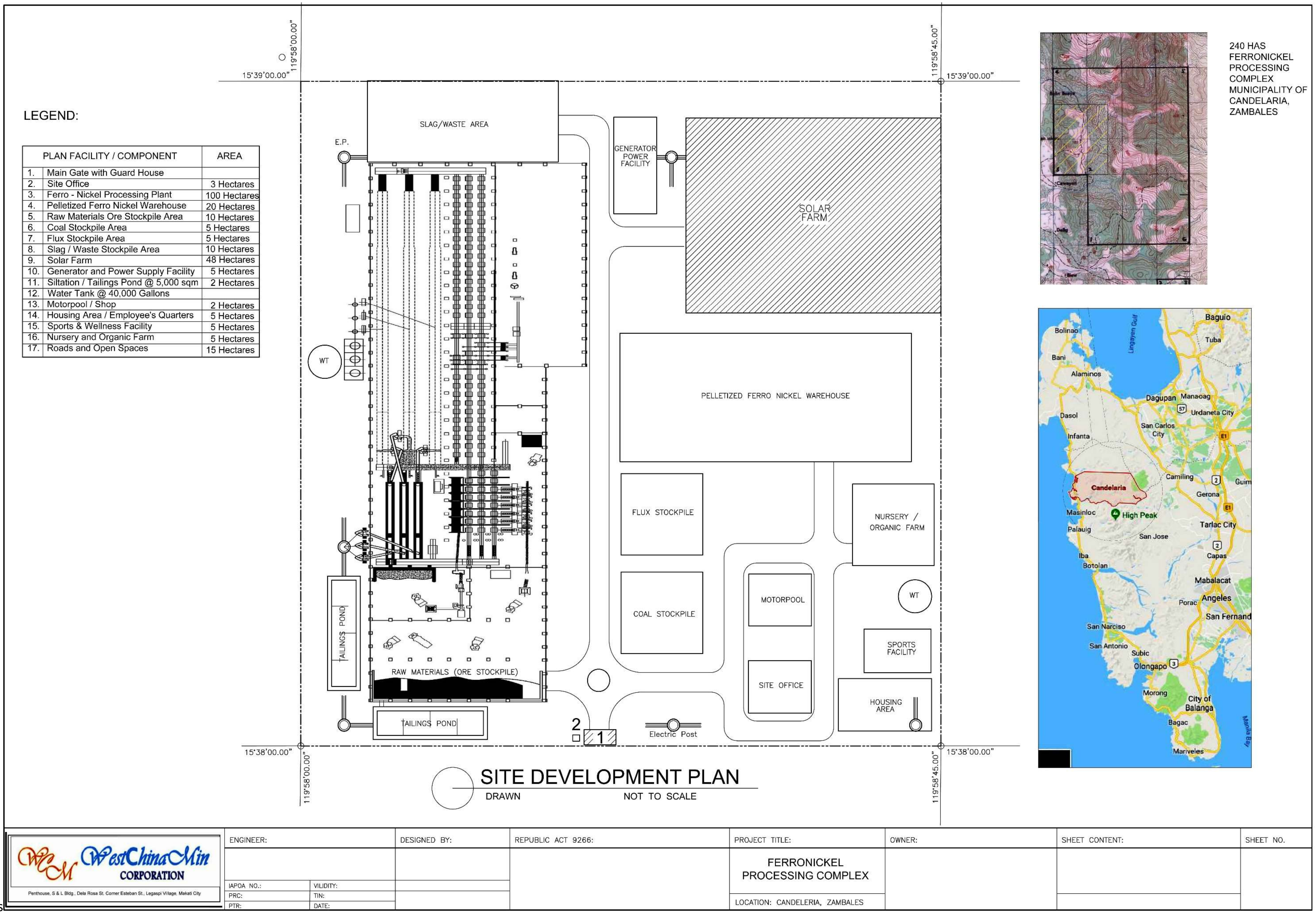


Figure 8 - Project Site Development Plan



	PLAN FACILITY / COMPONENT	AREA
1.	Main Gate with Guard House	
2.	Site Office	3 Hectares
3.	Ferro - Nickel Processing Plant	100 Hectares
4.	Pelletized Ferro Nickel Warehouse	20 Hectares
5.	Raw Materials Ore Stockpile Area	10 Hectares
6.	Coal Stockpile Area	5 Hectares
7.	Flux Stockpile Area	5 Hectares
8.	Slag / Waste Stockpile Area	10 Hectares
9.	Solar Farm	48 Hectares
10.	Generator and Power Supply Facility	5 Hectares
11.	Siltation / Tailings Pond @ 5,000 sqm	2 Hectares
12.	Water Tank @ 40,000 Gallons	
13.	Motorpool / Shop	2 Hectares
14.	Housing Area / Employee's Quarters	5 Hectares
15.	Sports & Wellness Facility	5 Hectares
16.	Nursery and Organic Farm	5 Hectares
17.	Roads and Open Spaces	15 Hectares

Figure 9 - Mill Complex Layout

1.6 Process Technology Option

1.6.1 Ferro-Nickel Plant Process Technology

This involves the construction if six (6) industrial production lines of nickel laterite ore low temperature reduction process utilizing microwave metallurgy and producing nickel alloy with a capacity of 300,000 metric annually.

The coal and flux will be pulverized and will be blended with the raw nickel ore. Coal will result to abrupt increase/raise in temperature of the material. On the other hand, flux will bond together the ROMO and the coal. From the mixer, the material (ROMO+coal+flux) will be subjected to high temperature using Microwave Technology. It will then pass thru the Low Temperature Reduction Section (from 1,500°C to 150°C) that will recover the ferro-nickel alloy through microwave metallurgy using bituminous coal as a reducing agent. From the LTRS, the nickel will be sprayed with water to cool the granules before going to the pelletizing plant. The nickel pellets will be the final product.

The slag and the nickel will be separated by magnets. The slag and pelletized materials are collected into a series of tank and will be washed and separated with magnet. The process is considered to be zero waste since all the slag can be converted in various types of tiles for flooring, roofing and walls for socialize housing in the mining community. It can also be use as a slag cement or for backfill materials for road construction. The slag will also be utilized for soil stabilization at bench area to prevent erosion.

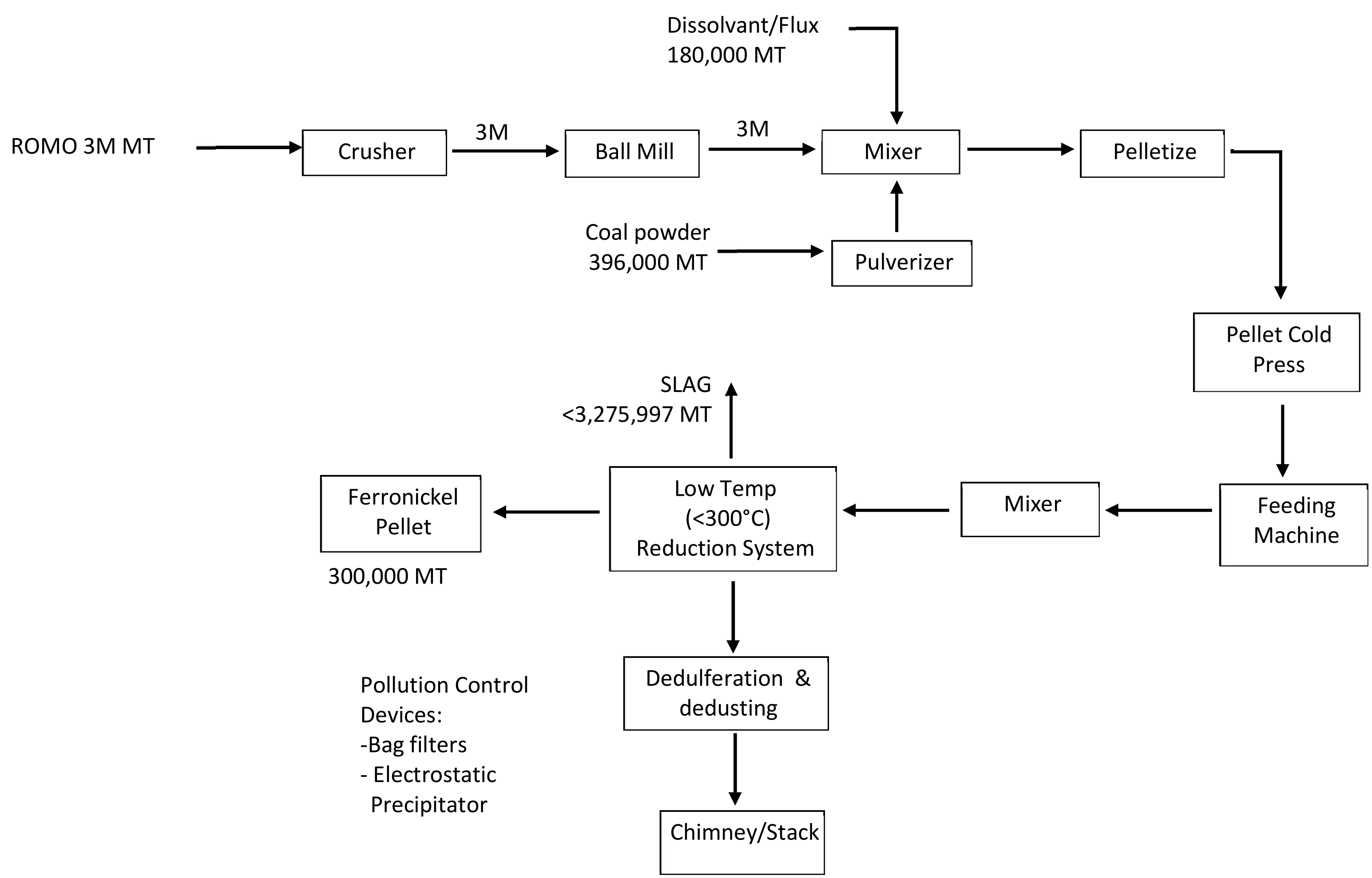


Figure 10 - Ferro-Nickel Plant Process Flow

1.6.2 Mining

In this project, the contour or strip mining will be used to mine the nickel ores. The main parameters to be observed are:

- At least 3-meter bench height; berm width at least 5 meters; bench slope at least at 60°; average pit slope shall be at least 45°
- Multi-level mining that provides flexibility in handling various grades and tonnages
- Mined-out areas may be used as waste dumps
- Multiple mining areas will be programmed as the need arises

Minimum of two active mining area will be maintained at all times to provide flexibility in operations and grade control. Mining area will start from the lowest elevation progressing upwards to higher elevations. Earth-moving equipment like backhoes, excavators or shovels and loaders in combination with dump trucks will be utilized. All run-of-mine ores will be hauled direct to drying stockyards or loading stockyards in preparation for processing.

The typical cross section of mining is shown in *Figure 11* and the general mining flowsheet is shown in *Figure 12*.

Figure 11 - Section of a Contour Mining Method

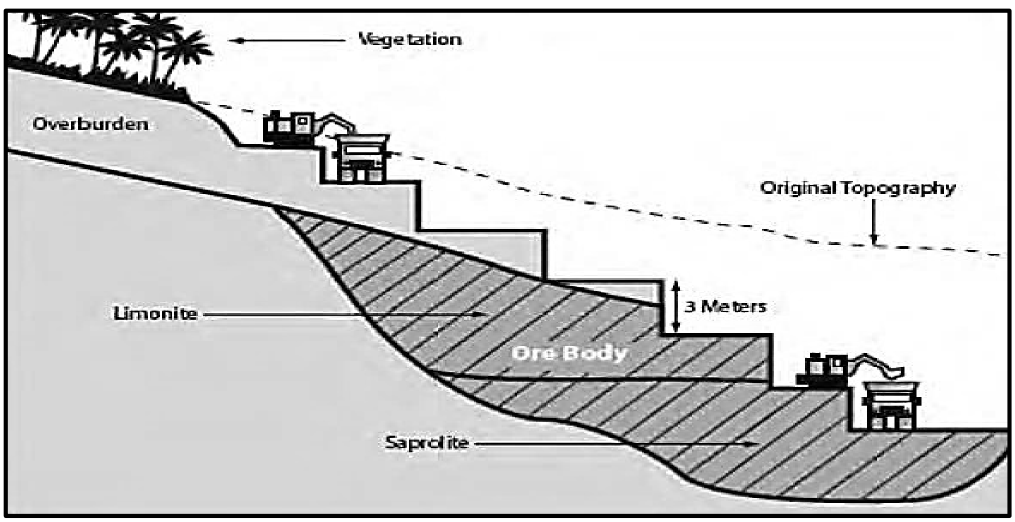
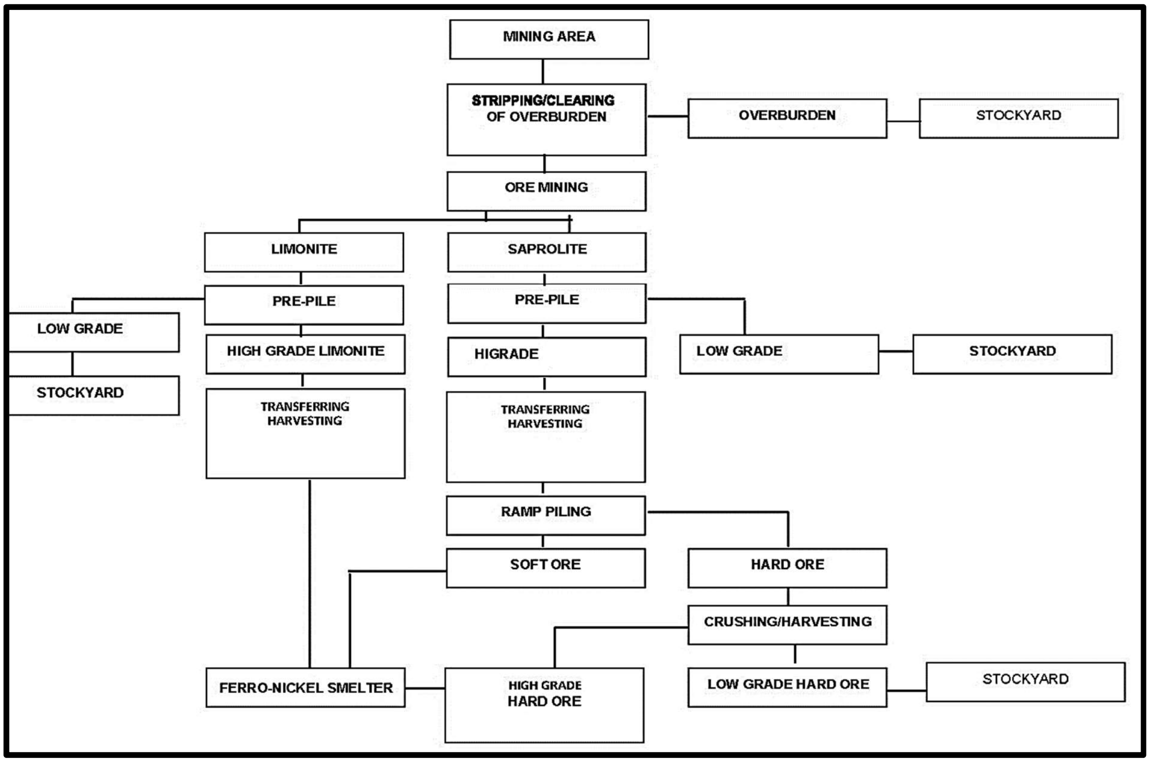


Figure 12 - Mining Flowsheet



1.6.2.1 Life-of-Mine (LOM)

The Project will have a minelife of fourteen (14) years based on its existing resource/reserve. This can be extended when additional resource/reserve are discovered/blocked during the continuing exploration activities within the LOM of the Project.

Table 12 - LOM Production Schedule

Year	Parcel				
	I*	II	VII	VIII	Total
1	600,000	600,000	600,000	-	1,800,000
2	700,000	700,000	700,000	-	2,100,000
3	800,000	800,000	800,000	-	2,400,000
4	900,000	1,025,204	774,796	-	2,700,000
5	1,500,000	1,500,000	-	-	3,000,000
6	1,500,000	1,500,000	-	-	3,000,000
7	1,411,505	1,588,495	-	-	3,000,000
8	-	3,000,000	-	-	3,000,000
9	-	3,000,000	-	-	3,000,000
10	-	3,000,000	-	-	3,000,000

Year	Parcel				
	I*	II	VII	VIII	Total
11	-	3,000,000	-	-	3,000,000
12	-	3,000,000	-	-	3,000,000
13	-	3,000,000	-	-	3,000,000
14	-	923,956	-	263,783	1,187,739
Total	7,411,505	26,637,655	2,874,796	263,783	37,187,739
* With existing ECC and approved DMPF, not included in this ECC application					

1.7 Project Size

1.7.1 Project Area and Capacity

The Project will be within Parcels I, II, VII and VIII of MPSA No.316-2010-III, Amended I. A summary of the Project components as distributed in the three (3) parcels are provided in the Table below.

Table 13 - MPSA No. 316-2010-III, Amended I

MPSA No. 316-2010-III	Ha.	Mining	Plant	Support Facilities
Parcel II	1,483.3508			
Parcel VII	164.7884			
Parcel VIII	82.4208			
Parcel I	286.251			
Total	**2,016.811**			

The Annual mining production would be 3,000,000 metric tons nickel laterite ore with the proposed plant producing 300,000 MT Ferro-Nickel pellets at 100% plant capacity.

1.7.2 Mineral Resource/Reserve

Based on the Philippine Mineral Reporting Code (PMRC) compliant Final Exploration Report (FER) prepared by Competent Person Geologists, the Project, including Parcel I (which already have a separate existing ECC and approved Declaration of Mining Project Feasibility, hence not included in this ECC application) the Measured resource of the area Is 4,710,831 MT with an average grade of 1.238% Ni and 30.95% Fe. Indicated resource is estimated at 38,559,850 MT with an average grade of 1.054% NI and 19.52% Fe. Moisture content of the nickel laterite is 35%.

Cut-off grade used was 0.55% Ni instead of the normal 1.00% Ni for direct shipping ore. More resources were blocked because the cut-off grade has been reduced to 0.55% due to the ferro-nickel smelter. The summary of the PMRC compliant FERs as prepared by CP Geologists are provided in the Table below.

Table 14 - PMRC Compliant Project Resource/Reserved

Location	Mineral Resource (WMT)	
	Measured	Indicated
Parcel I * (with ECC and approved DMPF) CP Geologist Rafael Liwanag	3,787,950	7,397,202
% Ni	1.223	1.345
% Fe	33.78	16.94
Parcel II, CP Balgamel Domingo		47,007,625
% Ni		0.970
% Fe		19.83
Parcel VII, CP Rafael Liwanag	922,431	3,689,523
% Ni	1.30	1.600
% Fe	19.34	20.67
Parcel VIII, CP, Balgamel Domingo		
%NI		465,500
%Fe		0.640
		21.1
Total/Average	4,710,831	58,559,850
% NI	1.238	1.054
%Fe	30.95	19.52

* With existing ECC and approved DMPF, not included in this ECC application

1.8 Project Phases

1.8.1 Pre-Construction Phase

The pre-construction phase will refer to the activities needed for the project expansion. It will involve acquisition of permits and clearances from concerned government agencies, entering into a Project Financing Statement, mapping and design for road routes, mining areas and other work sites; procurement and construction tendering, bidding of, and awarding to contractors. There will be no major land disturbances in this phase of the project except from the trampling of vegetation in the conduct of detailed surveys and mapping of access road and other work areas.

Major activities include: Project Planning; Environmental Impact Assessment and preparation of required documentation; Community Information and Consultation; Environmental and Community Management Systems Preparation; Feasibility Study, Work Programs, EPEP, SDMP, SHP and FMR/DP Preparations; Submission of DMPF, EPEP, SDMP and FMR/DP; Submission of Required Environmental Impact Assessment Report; Review by DENR-EMB and MGB; Issuance of ECC and Approval of DMPF; and Detailed Engineering and Permitting.

Table 15 - Pre-construction Phase Milestone

Activity	Month						
	1	2	3	4	5	6	7
Project Planning	»	»	»	»	»	»	»
Environmental Impact Assessment and preparation of required documentation	»	»	»				
Community Information and Consultation		»					
Environmental and Community Management Systems Preparation		»					
Feasibility Study, Work Programs, EPEP, SDMP, SHP and FMR/DP Preparations		»	»				
Submission of DMPF, EPEP, SDMP and FMR/DP			»				
Submission of Required Environmental Impact Assessment Report			»				
Review by DENR-EMB and MGB			»	»	»	»	
Issuance of ECC and Approval of DMPF							»
Detailed Engineering and Permitting						»	»

1.8.2 Construction Phase

The Construction Phase would involve the following:

- Improvement of the existing access road, as necessary;

- Additional haul and access road construction within the proposed project areas for additional support facilities, as necessary;
- Land preparation for, and construction or installation of mine and peocessing plant complex.
- Land preparation and construction of environmental facilities *(settling ponds/dams, overburden and waste rock dumpsites, drainage facilities, and Nursery)* and;
- Initial overburden stripping

Land preparation would generally involve clearing and grubbing, excavation/leveling, hauling of soils and drainage installation. The design of the drainage system would be dependent on the topography (terrain, contour) and existing gullies in the area. Mine haul roads would be developed in mining areas initially on natural topographic surface. These roads will be constructed with appropriate road base to allow safe and efficient traffic management. Setting of all facilities would consider the occurrence of natural hazards, minimization of surface and groundwater hydrological alterations, control of siltation to within allowable standard, minimization of major terrestrial ecological impacts, and avoidance as much as possible of socio-economic dislocations such as right of way or crop damages. These criteria would be applied to Technical/Engineering options and economic objectives of the Project. Construction will involve the implementation of the procurement and construction execution plans and detailed engineering designs of the plant complex. It is expected to last for1 year.

Table 16 - Construction Phase Milestone

Activity	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Procurement	»	»										
Construction of plant complex		»	»	»	»	»	»	»	»	»	»	»
Construction of assay laboratory and equipment motorpool			»									
Construction of sedimentation and settling ponds					»	»						
Construction of main access roads					»	»						
Construction of stockyards						»						
Mine equipment mobilization						»						

1.8.3 Operation Phase

1.8.3.1 Mining Operation

Mining operations are similar to other strip nickel mines with slight variations that are mostly due to topographical differences. First, the vegetation is cleared and the overburden is stripped. The limonite ore and saprolite ore are then mined using strip mining techniques. Each bench has a height of three (3) meters and a width of five (5) meters.

Production drilling would also be conducted on a 25 meters x 25 meters grid for better grade control. In-pit channel sampling would be conducted at three (3) meter intervals along each bench. These samples are assayed and each sample area is designated using colored stakes. As a result, we can easily determine which product we are mining and to which stockpile the ore must be transported based on its type and grade.

Clearing is done where significant vegetation is encountered. A bulldozer is used to do slight scraping and grubbing of vegetative remnants. After removing all the vegetative cover, stripping follows to remove the overburden and waste materials and uncover the ore. Since the material is heavily weathered and rippable, no blasting is required.
Stripping activities are accomplished using bulldozer-payloader-backhoe-dump truck equipment combination.

Excavated limonite, low-grade saprolite ore and waste materials are hauled and stockpiled to designated limonite stockpile, low-grade ore stockpile and waste stockpile areas. Pockets of boulders or raw hard ore occurring as floats are occasionally encountered during stripping. These materials are hauled for size reduction and segregation into low-grade boulders and high-grade boulders. Stripping advances until the ore zone is reached and ready for mining operation.

Due to the erratic and irregular ore distribution within the mining block, selective mining and ore segregation is employed. Actual extraction and ore segregation are guided by the results of face sampling and visual evaluation of the backhoe operator and/or grade-control supervisor.

Hydraulic excavators/backhoes are used to selectively draw the nickel ore. Materials are classed as soft ore (no boulders or lumps) and hard ore that contain significant amounts of the hard saprolite ores. It is further classified according to grade. Materials belonging to any of the soft ore classes are loaded, hauled and separately dumped on designated piling spaces within the Pre-Piling/Sun-Drying Area. Any limonite and saprolite waste materials excavated are also loaded, hauled and dumped in designated limonite stockpiles and waste stockyards.

Hard ores are mined using hydraulic breakers to a size just enough to be loaded to dump trucks. The boulders are further broken down and sorted according to ore grade classification. As in stripping, no blasting is required in mining.

Whenever saprolite ore would be mined, rocky portions of the site are segregated in order to maximize ore recovery. Oversized ore is then reduced in size either by mechanical means, using rock breakers, and/or by manual means. Limonite ore does not require size reduction. Soft saprolite ore is then solar dried by placing it in narrow piles and turning it over every several days.

Solar drying reduces moisture content of ore to a range of approximately 30% to 35%, which is suitable for the ferro-nickel smelter requirement. The nickel ore is then moved to the plant stockyards and piled, where it is covered with tarpaulins for dust control and for protection from rainfall.

The nickel ore is then delivered to the ferro-nickel processing plant for processing using quantities from various stockpiles in a manner that provides the proper mix of saprolite ore or limonite ore to meet the plant's specifications.

1.8.3.2 Processing Plant

The project will produce ferro-nickel pellets or granules from nickel laterite ores through a low temperature reduction process utilizing microwave technology. It is a new technology developed by the China Iron and Steel Research Institute which will be used in outside China for the first time.

In metal extraction processes, such as reduction or smelting, a source of energy is required for the endothermic reactions. This energy is often supplied by the combustion of carbonaceous materials or hydrocarbons or by inputting some electrical energy. Typically, large-scale reactors are used and the energy is transported to the reacting materials from the heat source via convective, conductive and radiative processes. Additionally, considerable heat is transferred to the containment vessel, the surroundings and the off-gases and this energy is difficult to recover. On the other hand, microwave heating systems can be designed such that only the material to be processed absorbs the microwaves, since microwave radiation is deposited directly in the material to be heated. Other potential advantages of microwave processing include; high energy densities, selective heating, improved control, environmental benefits and minimal off-gas generation.

The low temperature reduction process utilizing microwave metallurgy is composed of:

a. Materials Storage and Distribution
b. Material Forming/Mixing
c. Low Temperature Reduction and Grain Growth
d. Pulverized Coal Preparation

1.8.4 Project Closure and Decommissioning

The major activity involved in this phase is the decommissioning of remaining mining areas and the Plant. The closure and decommissioning activities will be implemented in consultation with the host communities through the Local Government Units.

2.0 ASSESSMENT OF ENVIRONMENTAL IMPACT

An Environmental Compliance Certificate (ECC) with Ref. no. ECC-CO-1602-007 was issued on 2016 covering the surface mining operation of nickel ore with an annual maximum production capacity of 1,000,000 wet metric tons encompassing a total area of 120 hectares. However, no project operation has been implemented except for exploration activities. Thus, with the proposed Project expansion, and following the guidelines of the Revised Procedural Manual for DAO 2003-30 and DENR Memorandum Circular 2010-14, this Environmental Performance Report and Management Plan (EPRMP) shall include the assessment of potential project impacts of the proposed project expansion incorporating the existing baseline data.

2.1 Land

2.1.1 Land Use Classification

2.1.1.1 Impact in terms of compatibility with existing land use

The municipality of Sta. Cruz has a total land area of 41,404 hectares, which constitutes 11.14% of the total land area of the Province of Zambales. It has a total urban area of 220 hectares which is subdivided into three (3) areas, Barangay Poblacion North, Barangay Poblacion South and Barangay Lipay. The other twenty-two (22) barangays are classified as rural areas.

Of the total land area of 41,404 hectares of the municipality of Sta. Cruz, 67% or 27,687 hectares have been classified as public forest. About 12,515 hectares are considered alienable and disposable lands. About 887 hectares are proposed industrial areas or ecozones. Timberland areas constitute 5,432 hectares. Forest reserves, which is set aside as watershed, covers 7,800 hectares and 1,208 hectares is set aside as civil reservation.

The municipality of Candelaria has a total land area of 33,359.19 hectares. Majority of which are classified as forestlands. Built up spaces are classified as residential as well as for other purposes like industrial and commercial establishments. Currently, the municipality is in the process of updating its CLUP. *Table 17* summarizes the land uses of both municipalities.

Table 17 - Landuses of Candelaria and Sta. Cruz

Land Use	Candelaria	Sta. Cruz	TOTAL
Agricultural	2,523.67	4,292.00	6,815.67

Land Use	Candelaria	Sta. Cruz	TOTAL
Industrial	0.00	18.00	18.00
Commercial	0.00	50.00	50.00
Residential	4,742.83	2,750.00	7,492.83
Institutional	0.00	20.00	20.00
Open space	26,092.69	5,402.69	31,495.38
Others	0.00	31,313.31	31,313.31
TOTAL	**33,359.19**	**41,404.00**	**77,205.19**

A significant portion of the area of both municipalities are used for mineral production.

2.1.1.2 Encroachment in Environmentally Critical Areas (ECAs)

The province of Zambales belongs to the Central Luzon Water Resource Region wherein two major river basins, Agno River and Pampanga River, can be found. The province adjoins the western border of these two river basins. Mines and unproclaimed protected area can be found on the upper western portion of the province. The proximity of the project area to major river basins, critical watersheds and protected areas is shown in *Figure 13*. Project encroachment in areas frequently visited and/or hard-hit by natural calamities is provided in 2.1.2.4 . In summary, types of ECAs within the project site include geologic hazard areas and areas prone to volcanic activities/earthquakes.

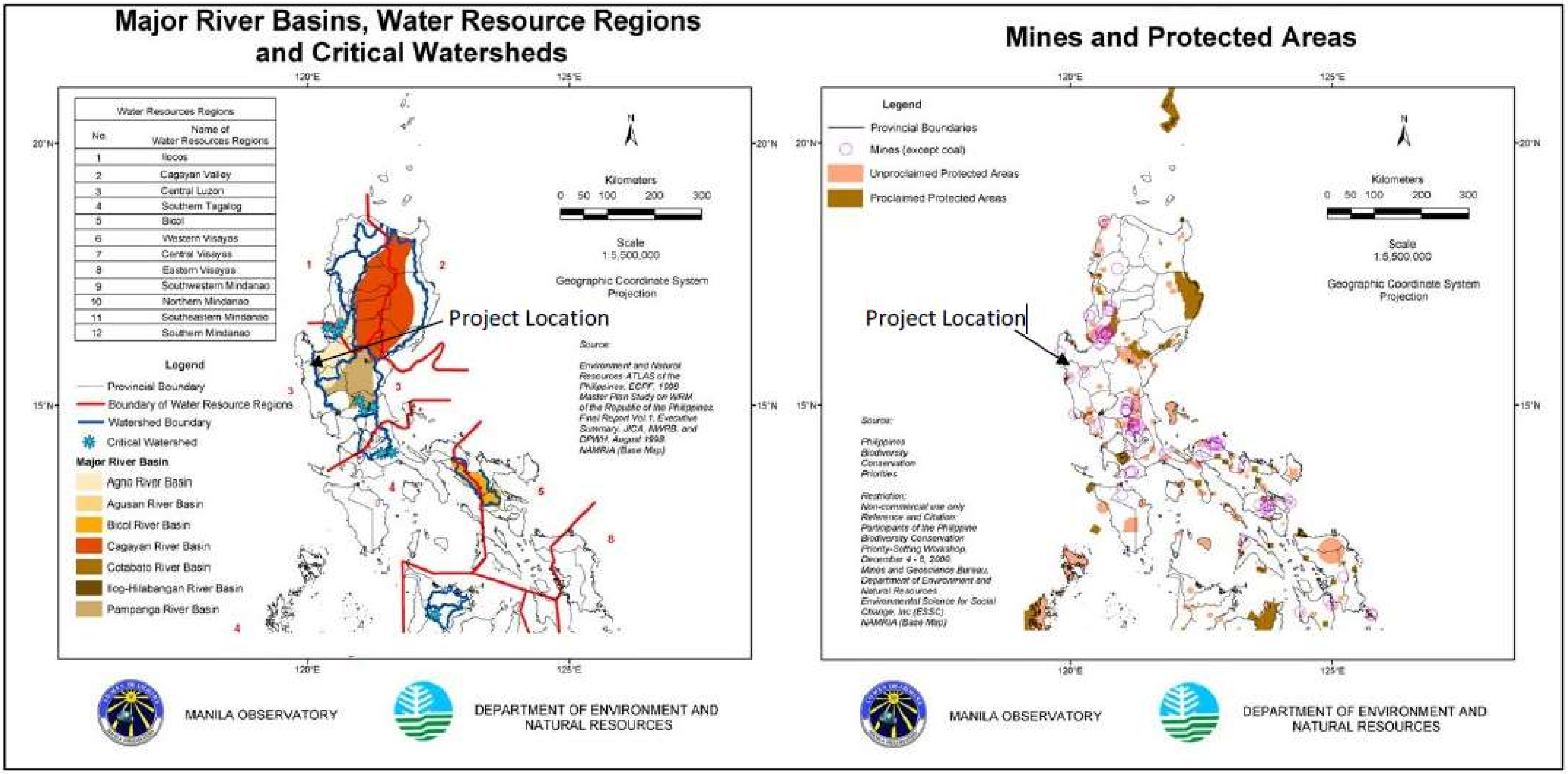


Figure 13 - Project Location with respect to Protected Areas and Critical Watersheds

2.1.1.3 Impact in existing land tenure issue/s

There are no known CARP areas/CARP-related issues within the project area.

2.1.1.4 Impairment of visial aesthetics

The mining activities will have permanent and irreversible impact on the slopes and natural topography of the MPSA area. It will require the removal of vegetation from the active mining area and the eventual excavation of mineral ore thereat. These changes will be confined within the MPSA area which is far from residential areas.

The progressive rehabilitation program of the project ensures the re-greening of the area according to its final landform design. Careful planning and timely execution of environmental plans shall be observed by the company to safeguard not only the interests of stakeholders, but also the environment. Good housekeeping will be done along with the implementation of the reforestation program. This will contribute to the maintenance of a tidy and a well-preserved working environment.

2.1.1.5 Devaluation of land value as a result of imptoper solid waste management and other related impacts.

The expected increase in population due to possible migration of mine workers would result to increased of solid waste generation in the area. Solid wastes that may be generated by the employees and laborers of the project include plastics, paper, tin cans, bottles, etc.

Solid wastes generated will be managed through the implementation of ecological solid waste management system. Garbage bins will be provided within and outside of the plant complex and will be located in strategic location to alleviate the possible contamination to land resources.

2.1.2 Geology/Geomorphology

2.1.2.1 Change in surface landform/geomorphology/topography

2.1.2.1.1 Geomorphology

The area within and outside the project site is generally characterized by hills and ridges with heights ranging from 325 to 489 masl, with well developed drainage systems within the project site. In the west side, the coastal zone is made up of flat plains with some occurrences of hills. The coastal plain is located in the northwestern part of the area. It is characterized by a relatively flat lying area, with several rivers and creek systems cutting across. The area is underlain by Bani clay soil. The hills and slopes, corresponds to the areas underlain by sedimentary rocks and the Zambales Ophiolite Complex lithologies. This marks the start of increasing elevation as one goes from west to east. Several fault structures were mapped in this part of the project site. The ridges and spurs are the dominant morphological features in the area. This part of the project site is generally underlain by ultramafic rocks and where the highest peaks of the area can be found. The geomorphology of the project site and nearby areas is dependent on the interaction of several factors; the underlying lithologies, geological structures that cut the area, soil and prevailing slopes, the amount of rain falling on the project site and, in the site context area, the type of climate and the occurrence and duration of the extreme meteorological – hydrological events (e.g. typhoons, floods). The interaction of these factors determines the frequency, magnitude and intensity of the hazards the corresponding risks posed in the project site and its site context area.

2.1.2.1.2 Slope

Slope has great effect on soil erosion. The greater the slope gradient, the greater the velocity of runoff and therefore exhibits higher reduction of soil particles, on steep slopes, high velocities of water flow causes erosion by scouring and sediment transport. The project site is generally characterized by steeper slopes (between 5 and 20 degrees) as shown on *Figure 14*.

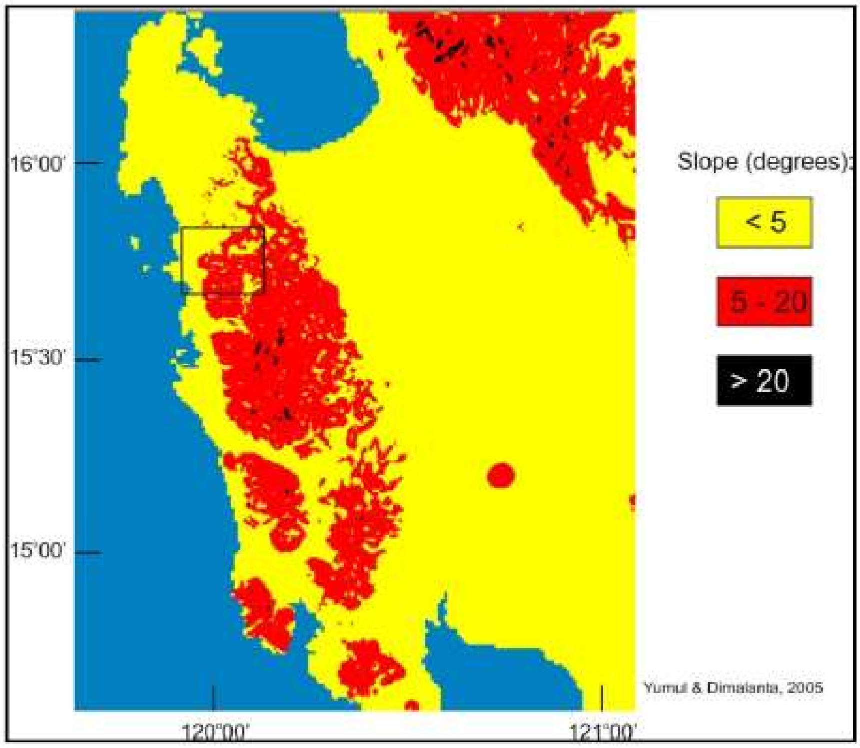


Figure 14 - Slope Map

2.1.2.2 Change in sub-surface geology

2.1.2.2.1 Regional Geology

Essentially, the N-S oriented Zambales Ophiolite Complex (ZOC) is made up of a complex of oceanic crust consisting of an ophiolite sequence made up of a lower harzburgite/ peridotite (including pyroxenites and hornblendites. With some garnets), layered cumulate rocks, largely dunite, where chromite (and some associated platinum group elements and nickel sulfides, including magnetite are observed); limited plagiogranites, microdiorites, pegrnatites and anorthosites; followed by isotropic gabbros, diabase dikes and pillow basalts. Fringing these rocks are pelagic sediments.

Interpreted as a supra-subduction zone ophiolite, it has been estimated to be Eocene in age, serpentinized and chloritized at many places as replacement or alteration of ferromagnesian minerals, and stratigraphically comprises a complete sequence capped by pelagic SQdiments of the Late ~oce.ne Aksitero Formation. An unconformity separates the ophiolites with later Middle Miocene to Recent sediments, carbonates and volcanic rocks. Unconsolidated gravels mark most of the stream valleys extending the alluvial cover towards the coast to the west. The Zambales Ophiolite Complex(ZOC) comprises of two blocks, the Coto Block (associated with a midoceanic ridge) and the Acoje Block of island arc affinity. These two blocks are found in the northernmost Masinloc Massif, with another one to the south (Cabangan Massif) and the southernmost one, the San Antonio Massif, all bounded by faults.

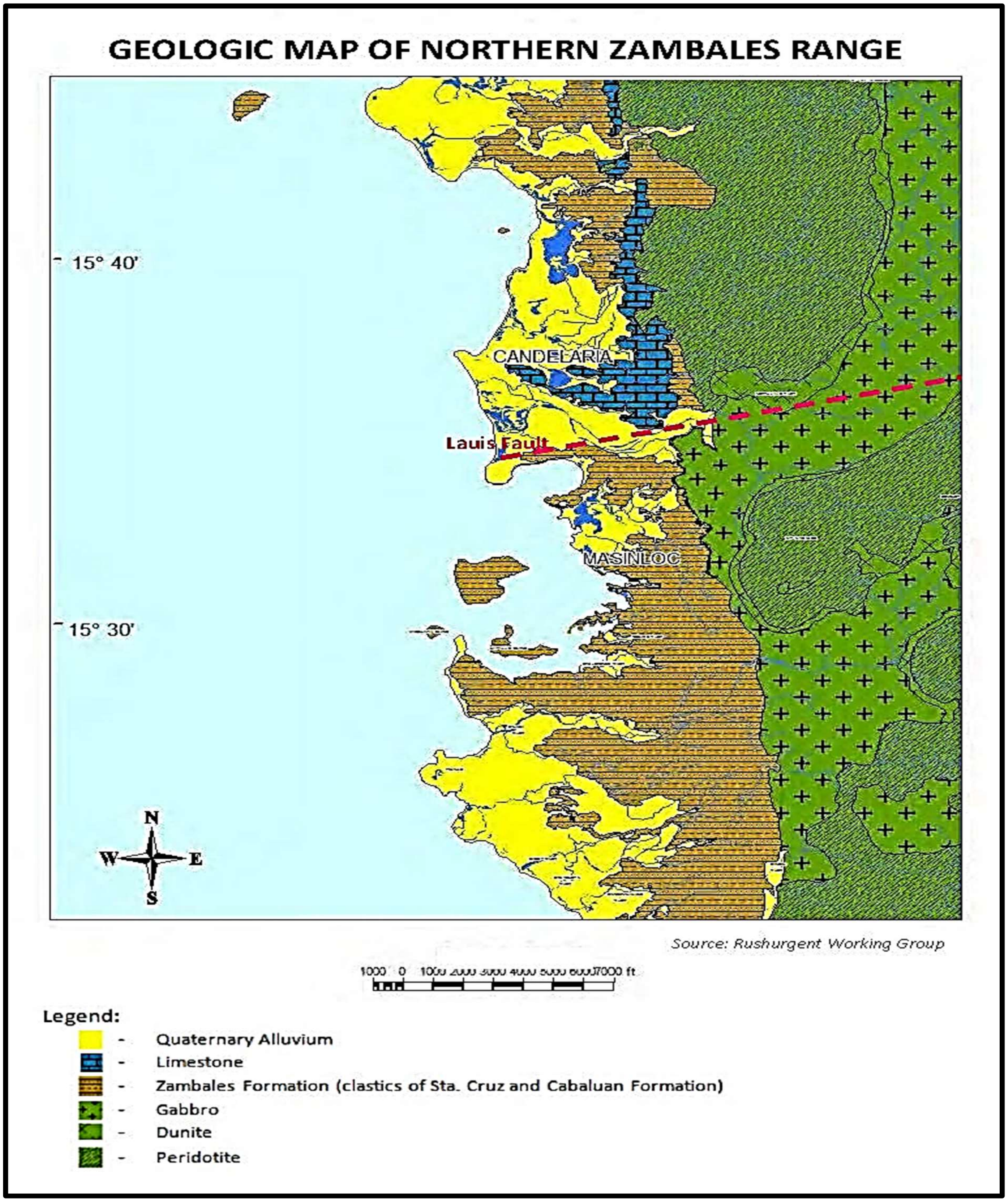


Figure 15 - Regional Geologic Map, Northern Zambales

2.1.2.2.2 Sequence Stratigraphy Column of Rock Units

The project site is situated within the northern portion of the Zambales – Bataan volcanic terrane. The vicinity of the project site is predominantly underlain by three lithologic formations; the Zambales Ophiolite Complex, the Cabaluan Formation and the Quaternary Alluvium.
The western margin of Luzon is underlain by the Zambales Ophiolite Complex which is divided into three massifs – Masinloc, Cabangan and San Antonio. The Masinloc massif is further subdivided into the Acoje and Coto Blocks. In terms of petrography and geochemistry, the Acoje Block is similar to the San Antonio massif whereas the Coto Block shares similarities with the Cabangan Massif (after Yumul, 1990).

The Zambales Ophiolite Complex, which lies in the western margin of Luzon, is a 160 km long and 40 km wide, north south trending complete ophiolite sequence. The ophiolite units included are harzburgites and lherzolites, ultramafic and mafic cumulates, dike-sill complexes, and volcanic rocks. The complex is divided into three massifs; Masinloc, Cabangan and San Antonio. The Masinloc massif is further subdivided into the Acoje and Coto Blocks. In terms of petrography and geochemistry, the Acoje Block is similar to the San Antonio massif whereas the Coto Block shares similarities with the Cabangan Massif (after Yumul, 1990).

Overlying the Zambales Ophiolite Complex are pelagic to hemipelagic limestone and clastic rocks (e.g. Villones, 1980; Schweller et al., 1984) known as the Aksitero Formation. The dating based on foraminiferal assemblage found in the limestone yielded a Late Eocene to Early Oligocene age (Amato, 1965 in Aurelio and Peña, 2004). The ophiolite complex has, thus, been assigned an Eocene age (e.g. Yumul, 1990), consistent with the whole rock K-Ar age of a dike from Coto Mine which yielded an age of 46.6 + 5.1 Ma whereas a sill sample from Sual, Pangasinan gave an age of 44.3 + 3.5 Ma (Fuller et al., 1991).

On the western foothills of the Zambales range, uncomformably overlying the Aksitero Formation is the Cabaluan Formation which was formerly called the Zambales Formation, or the Zambales Limestone and Conglomerate by Corby et al. (1951). The unit is an S-shaped belt observed in Naluo Point, Sta. Cruz, Zambales. Karig and others (1986) proposed renaming the unit as the Cabaluan Formation because of the well-developed sequence exposed along the Cabaluan River. The exposure of the lower clastic member consists of conglomerate, sandstone and siltstone, that are massive to moderately bedded with some portions exhibiting cross bedding. This formation has been assigned an age not older than Middle Miocene based on the observed foraminiferal assemblage which includes *Orbulina universa* (Aurelio and Pena, 2004) while the foraminiferal assemblage from the calcarenites at the top of the limestone member yielded a late Late Miocene age (Karig et al., 1986). *Figure 16* shows the Lithologic formations within the project site vis-à-vis the Zambales Range (Aurelio and Pena, 2004).

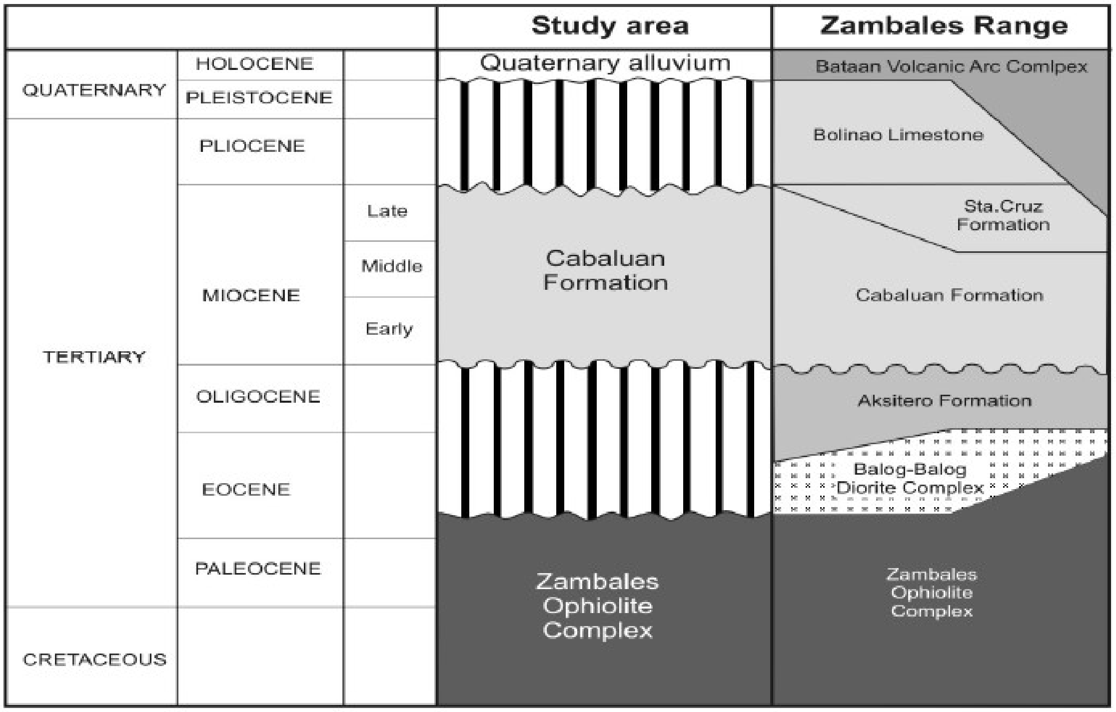


Figure 16 - Sequence Stratigraphic Column of Rock Units

2.1.2.3 Impact Assessment

2.1.2.3.1 <u>Impacts on Geology and Geomorphology</u>

Pre-construction/pre-operational and construction/operational activities that would generate most

significant impact to geology and geomorphology is plant and road construction, overburden removal and ore extraction. Surface mining activities causes permanent alteration of the original topography. In particular, earth moving activities in the mine site especially the disturbance of areas on steep slopes during operation/ore extraction may result in slope stability problems and cause the collapse of these critical areas. Risk of ground instability resulting to failure of the pit wall may pose danger to project personnel, equipment or structures. Mine subsidence, on the other hand, is one of the risks associated with underground mining. Ground movements of the earth's surface due to the collapse of overlying strata into voids created by underground mining may cause damage to buildings and roads.

2.1.2.3.2 Mitigating Measures

Impacts of mining on geology and geomorphology will be prevented or managed through:

- Geotechnical site investigation;
- Implementation of suitable engineering measures and geotechnical design prior to and after the earthworks;
- Properly managed benching of the mining areas (benches are restricted to at least 5 m wide);
- Adequately reinforced underground tunnels;
- Developing mine haul and access roads following topographic surface contour with a maximum road gradient of 6.0%;
- Adoption of pre-emptive measures through implementation of appropriate slope/ground failure monitoring plan to identify any instability at an early, non-critical stage so that safety measures can be initiated to prevent or minimize impacts and;
- Training/educating project personnel/workers on various slope/ground failure modes, hazard warning signs and standard operating procedures (SOPs) to be observed in case of the events mentioned.

2.1.2.4 Inducement of subsidence, liquefaction, landslides, etc.

2.1.2.4.1 Earthquake Hazards (Seismic Hazards)

Regional seismicity suggests vulnerability of the area to earthquake hazards. Intense ground shaking is the main hazard associated with earthquakes, with ground rupture/fissuring, liquefaction and landslides as collateral hazards. The degree and extent by which the area is affected by these seismic hazards will be dependent on the magnitude of the earthquake, proximity to the earthquake source (epicenter), and site ground condition.

The potential earthquake generators that may affect the project area as shown in *Figure 17* include the East Zambales Fault, Manila Trench, the Maraunot Fault passing through Mt. Pinatubo and Mt.Pinatubo itself. Based on existing preliminary work of PHIVOLCS, there is relevant active faulting at least along the northern segment of the East Zambales Fault which is nearest to the site. Most of the epicenters are shallow so indicating that faulting is still active. The province of Zambales is at high risk to earthquakes as shown in *Figure 18*. The calculated annual seismic rates given by Thenhaus and others (1994) was used to derive the estimation of earthquake frequency for earthquakes of a given magnitudes (Ms) greater than 5. *Table 18* gives the summarized result. The seismic source zone used is Zone 8 with an area of 74,667 km2.

Table 18 - Annual Rates of Earthquake Activity by Magnitude Intervals and Interval of Years for Seismic Source Zone 8

Magnitude (Ms)	Annual Rate (Number/Year)	Interval (years) of occurrence
5.2 to < 5.8	0.32081	3
5.8 to < 6.4	0.12024	8
6.4 to < 7.0	0.04505	22
7.0 to < 7.3	0.01689	59
7.3 to < 8.2	0.00633	157

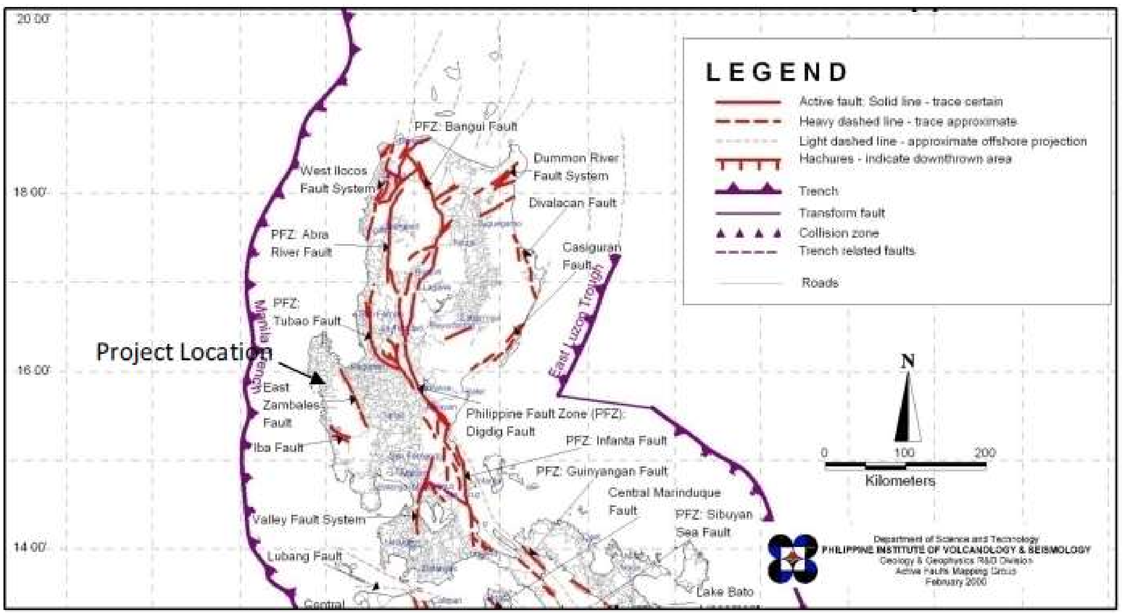


Figure 17 - Distribution of Active Faults and Trenches

The Intensity of ground shaking is also dependent on the ground condition of the area. Depending on the ground condition two categories were used; medium soil and rock. The general bedrock condition of the site suggests that estimated peak horizontal acceleration would range from 2.0-2.5g. If we consider the East Zambales fault which is an active fault with assumed slip-rates of 1cm/year, the acceleration amplitude is 4.9g.

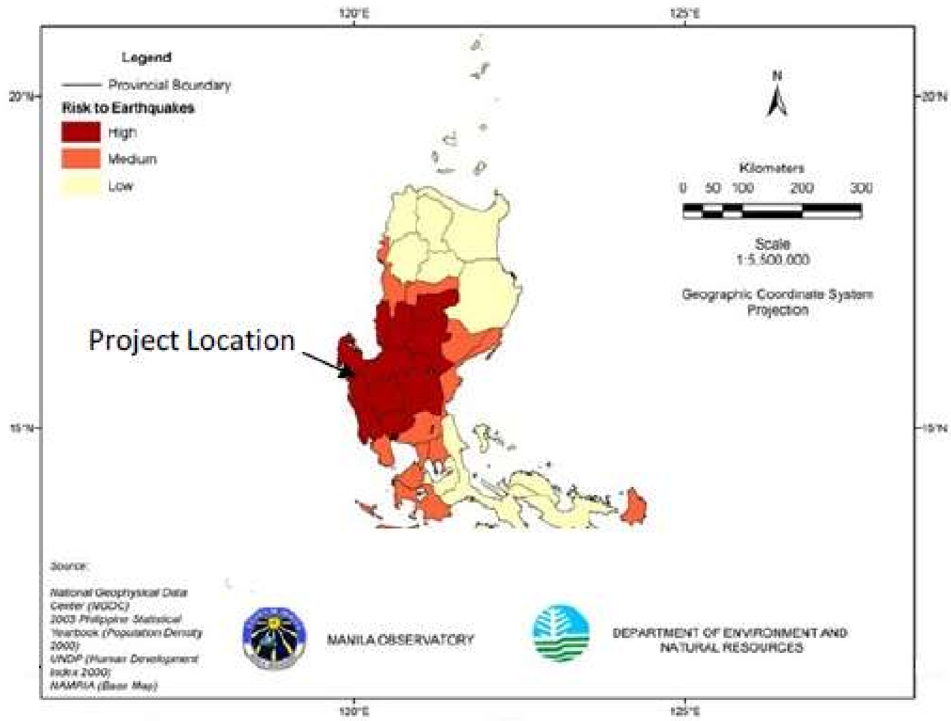


Figure 18 - Risk to Earthquakes Map

2.1.2.4.2 Groundshaking

Ground vibration or shaking results from the passage of seismic waves produced during an earthquake. The intensity of ground shaking is dependent on the magnitude of the earthquake, proximity to the source, and ground condition. Impacts include damage and destruction of buildings and ground failure. Estimates of ground-motion hazards for the project were adopted from regional studies derived Thenhaus and others (1994). Depending on ground condition three categories were adopted; soft soil, medium soil and rock. The geotechnical properties of the project area indicate ground condition similar to soft soils as defined by Fukushima and Tanaka (1990), and subsequently adopted by Thenhaus and others (1994) for the Philippines. Expected ground shaking intensity for this type of ground, considering a modelled earthquake event of Ms 8.2 with a 10 percent probability of exceedance in 50 years, would range from 0.6-0.7 *g* – where *g* is the acceleration due to gravity *Figure 19*.

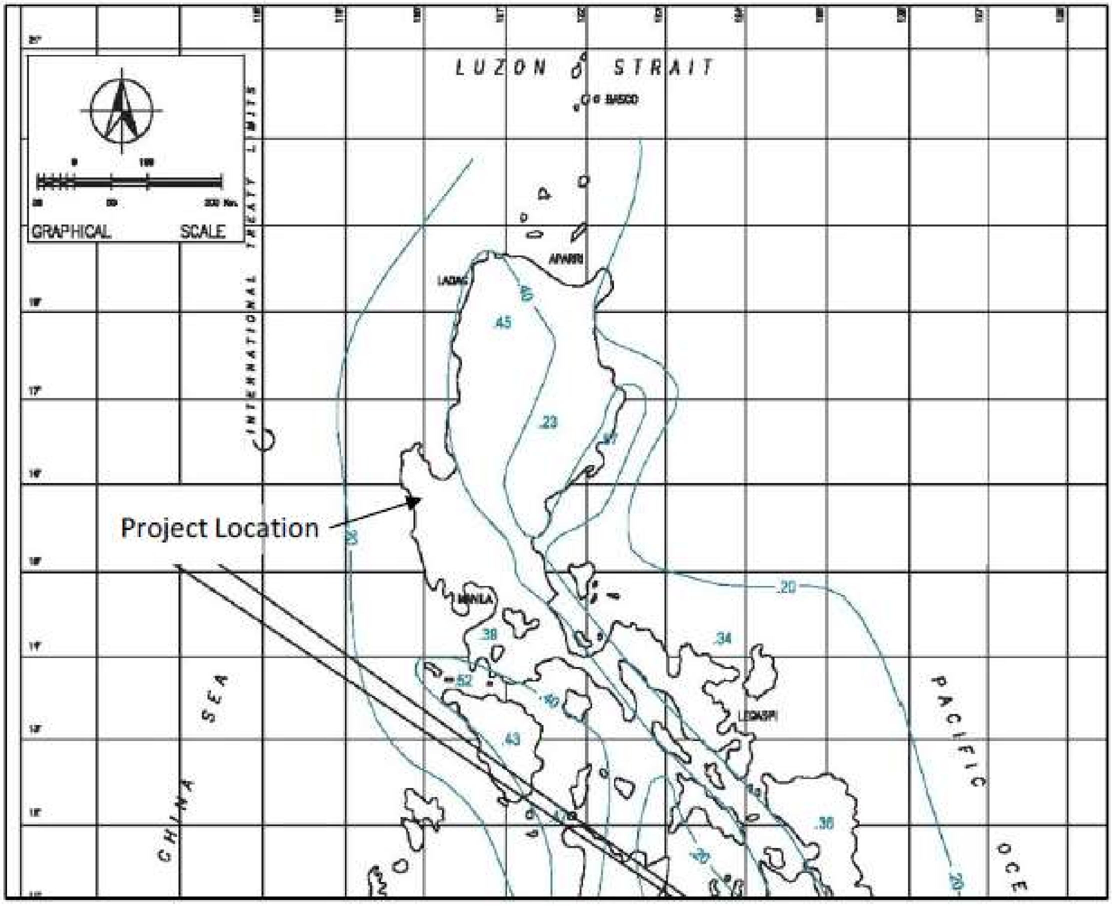


Figure 19 - Estimated Peak Horizontal Ground Examination

2.1.2.4.3 Liquefaction and Differential Settling

Liquefaction is the process in which sediments, consisting mostly of water-saturated silt and fine sand, lose rigidity in response to earthquake-induced intense ground shaking. As particles are reorganized into a more compact packing arrangement, pore water is expelled and breaks through the surface forming sand boils. The process is prevalent in seismically active areas underlain by water-saturated, moderate to well-sorted sandy sediments, and where the water table is relatively shallow.

Based on the soil textural class of the Project area, susceptibility to liquefaction and differential settling would be minimal since the area is generally comprised of fine-textured clay soils. It would be prudent, however, to conduct site specific geotechnical foundation test within zones where underground mining and infrastructure facilities that would exert considerable loading pressure on ground foundation (e.g. water tank) would be placed. Liquefaction susceptibility map is shown in *Figure 20*.

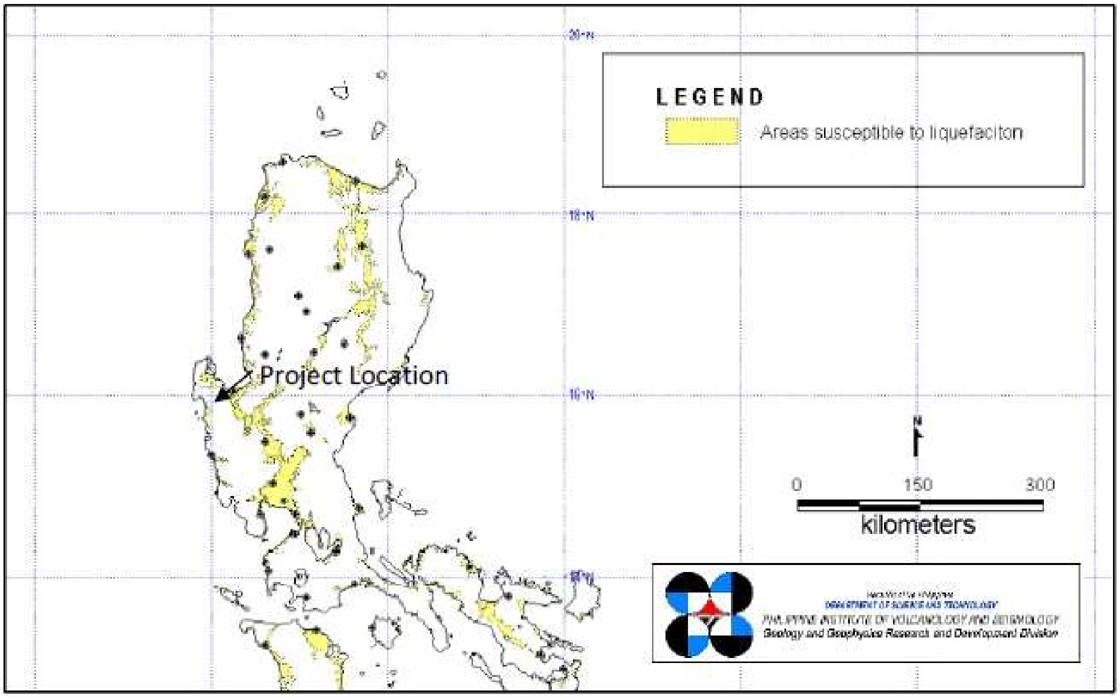


Figure 20 - Liquefaction Susceptibility Map

2.1.2.4.4 <u>Risk to Tsunamis</u>

The entire province of Zambales is classified to be at high risk to tsunamis as shown in *Figure 21*. Tsunamis can be generated along faults extending into the sea, provided that the earthquake originated at the shallow depths, and its magnitude is sufficiently high (e.g., 7.0 magnitude).

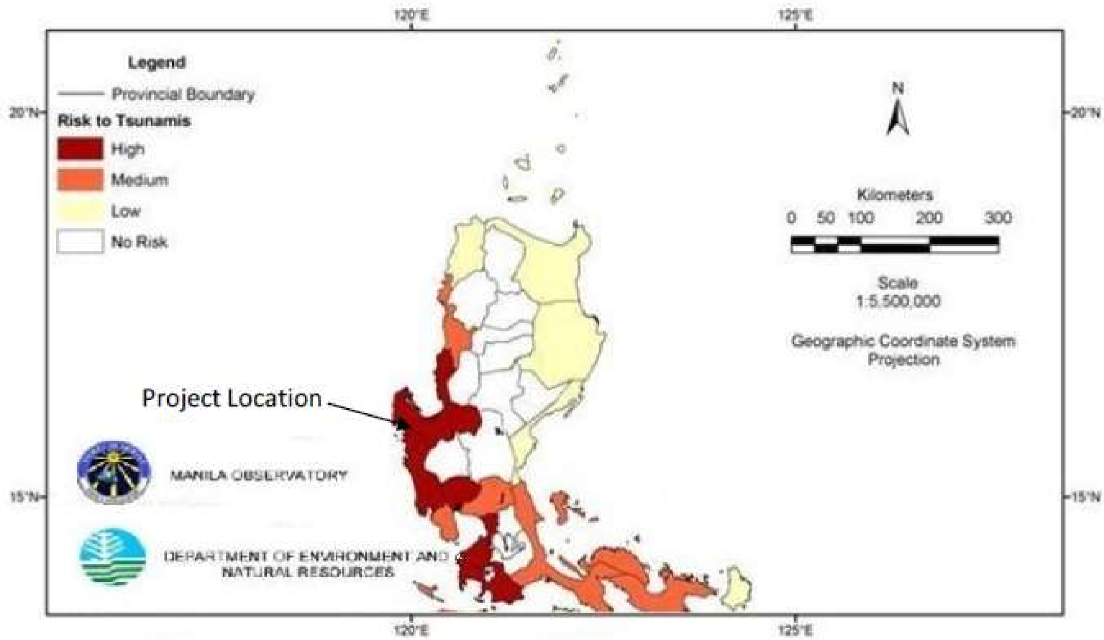


Figure 21 - Risk to Tsunamis Map

2.1.2.4.5 <u>Volcanic Hazards</u>

The only known active volcano proximal to the site is Pinatubo volcano, which last erupted in June 15, 1991. Long-term forecast for Pinatubo Volcano suggests that future eruptions shall be significantly less explosive compared to that of the June 15, 1991 eruption. Volcanic eruption is anticipated to be a mildly explosive dome-forming (outpouring of viscous lava) activity centered and possibly confined (at least during its initial eruptive stage) within the summit caldera structure of the volcano. Eruption-associated volcanic hazards at Pinatubo Volcano include airfall tephra, pyroclastic flows and surges related to eruption column collapse and dome-growth. Of these, only airfall tephrarelated and pyroclastic flow hazards are expected to affect the site.

Areas most vulnerable to tephra fall are those proximal to the active crater of Pinatubo, the thickness of the deposit dependent on the speed and direction of the prevailing wind, height of the eruption column, and duration of the eruption. Hazards include burial by volcanic ash, and impact from large projectiles. Estimated thickness of tephra that may be deposited in the area should eruption intensity be similar to the 1991 eruption would be <10 cm. Maps of volcanic hazards and risk to volcanic eruptions are shown in *Figure 22*.

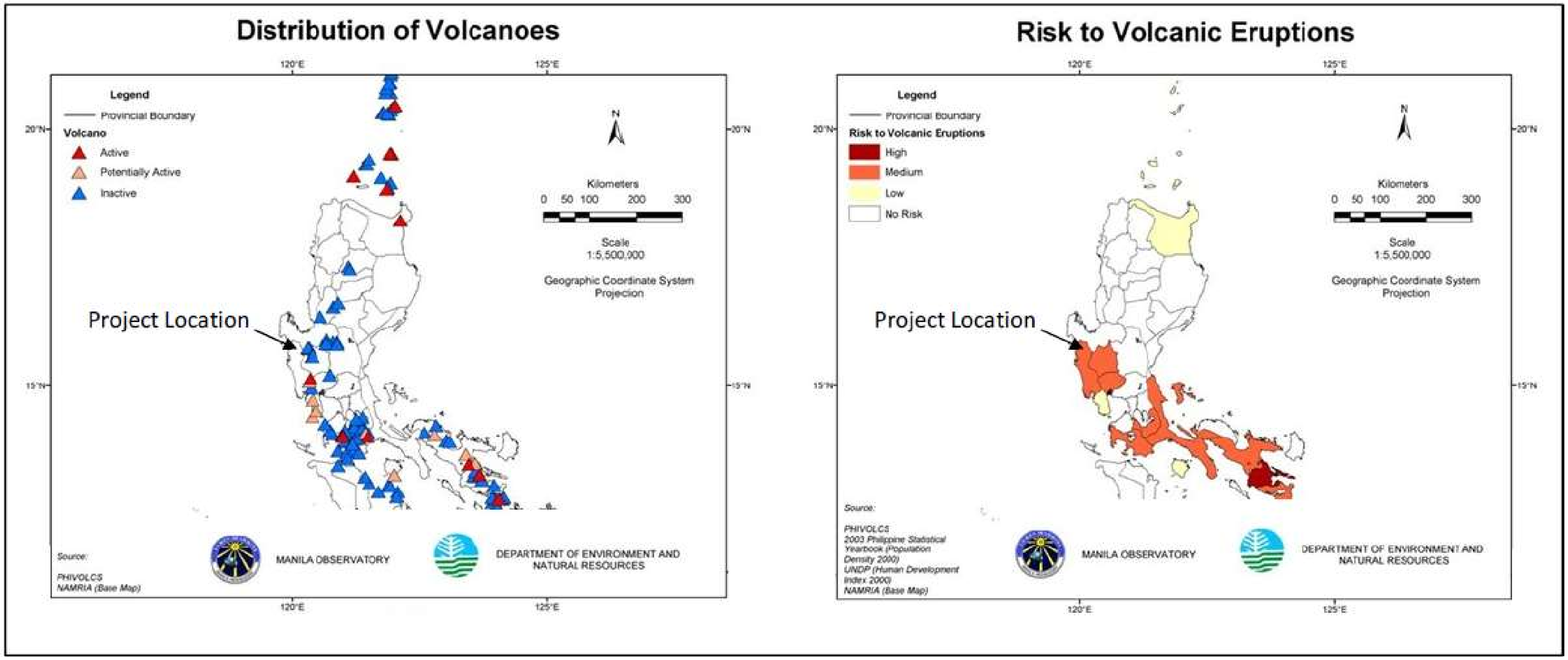


Figure 22 - Volcanic Hazards and Risk to Volcanic Eruptions Map

2.1.2.4.6 Impact Assessment

2.1.2.4.6.1 Topography and Drainage

Excavation works will result in major alteration of surface drainage condition leading to localized flooding near the vicinity of the work areas. A network of temporary drain canals should be designed and constructed to efficiently route runoff towards existing natural drainage system. This temporary drain network must be complemented with a series of sediment traps and interceptor structures to prevent sediment incursion into natural drainage system.

2.1.2.4.6.2 Groundwater Contamination

Potential contamination of shallow aquifer system of the area may occur as a result of wastewater infiltrating into the ground in the event of failure or breakage of the wastewater treatment facility and the sewer line. This shallow aquifer system is being tapped for domestic use by nearby communities. Such event can be avoided by conducting regular maintenance of pipeline and treatment structures. As added precaution in aid of monitoring, shallow monitoring wells must be established down slope of the treatment facility to identify potential incursion and migration of wastewater contaminants within the shallow aquifer systems.

2.1.2.4.6.3 Earthquake induced Ground Shaking

As indicated by the geotechnical properties of the project, the ground condition is similar to soft soils as described by Fukushima and Tanaka (1990), and afterward adopted by Thenhaus and others (1994) for the Philippines. Thus, the infrastructure facilities should integrate expected intensity of earthquake-induced ground shaking in their seismic safety engineering design, where the potential ground acceleration intensities ranges from 0.6-0.7 *g*. This is to ensure that infrastructure does not experience undue intensification of ground shaking condition during earthquakes.

2.1.2.4.6.4 Pyroclastic Flows and Lahars

Hazards from pyroclastic flows and surges include burial, impact by fragments, incineration and emission of hot gases. Such hazard may affect only the uppermost portion of the volcano to a distance of 16 km from the active vent along the Sacobia River, based on areas affected by pyroclastic flows during the 1991 eruption. As stated previously, future eruption is likely to be less explosive, hence areas affected may not be as extensive as those affected in 1991.

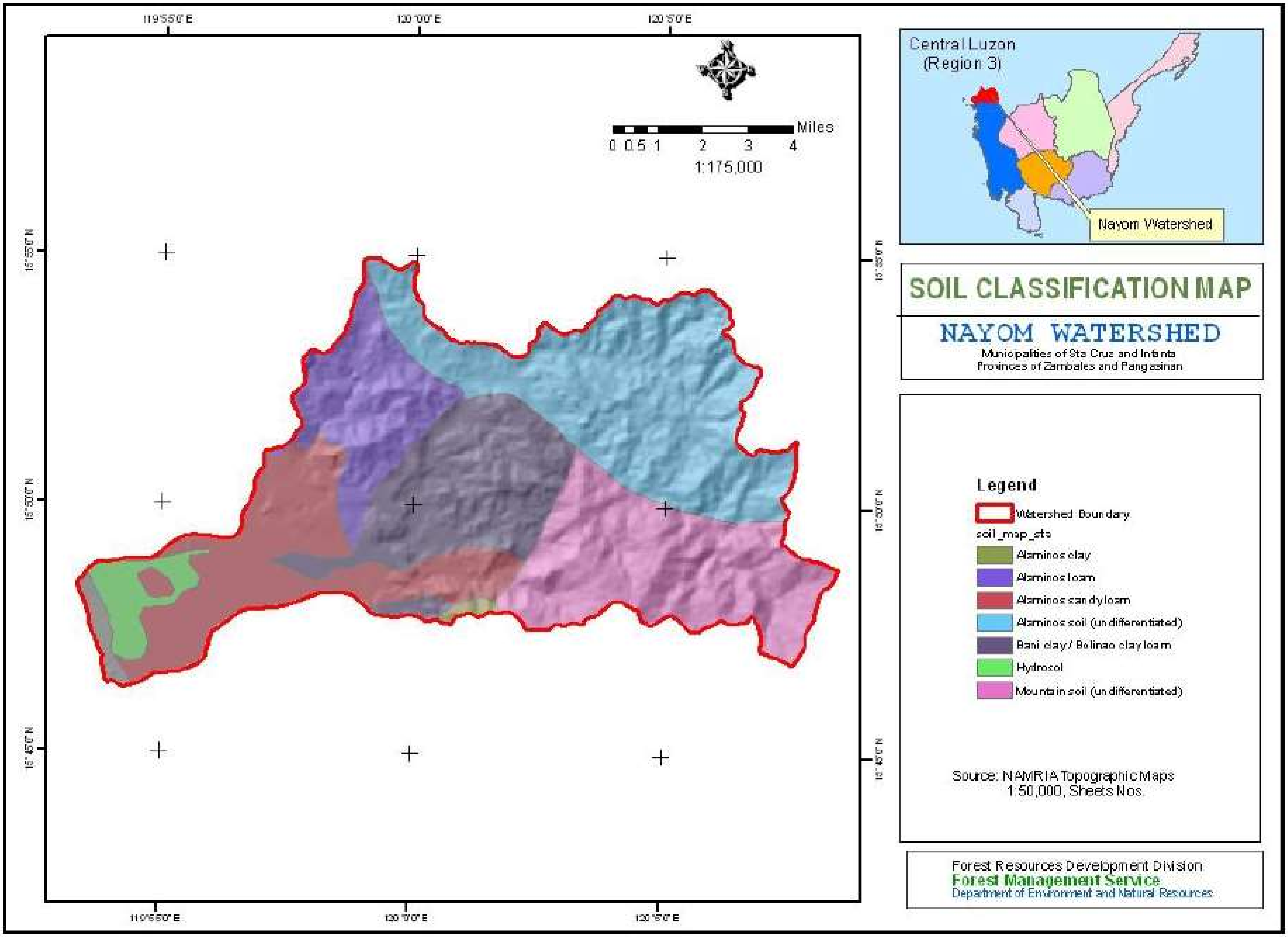
2.1.3 Pedology and Land Use

2.1.3.1 Pedology (Sta.Cruz Area – Current ECC) (EISWestChinaMin, 2016)

Various soil types are found in Sta. Cruz, including hydrosol (in swamps and marshes), La Paz series found in the plains, and the Bani series and Alaminos series which are both found in the uploads. The site is underlain by the Alaminos Clay. The soil belongs to the lateritic soils which has strong brown colour because of the un-hydrated iron oxides present in soil. Variations in shade are observed depending on the amount of moisture, organic matter content and the extent of weathering of the parent material. The depth of the soil profile ranges from less than a meter to about eight meters to the decomposing bedrock.

The Alaminos Clay tends to become lighter in colour within the deforested areas, with shades varying from orange to reddish brown. It also becomes columnar, porous and turns loose, silt loam to clay loam in the deforested areas. The Alaminos clay is sticky when wet but friable when dry. In terms of agricultural importance, the Alaminos Clay is insignificant because it is mostly found in areas with high relief and generally rugged topography. Based on the data gathered from the Bureau of Soil and Water Management (BSWM), there are seven (7) types of soil found in Nayom Watershed namely: Alaminos Loam (11.34%); Alaminos Sandy Loam (17.94%); Alaminos Soil (undifferentiated) 29.04%; Bani Clay/Bolinao Clay Loam (16.39%); Mountain Soil (undifferenciated) 21.54%; Hydrosol (3.26%) and Alaminos Clay (0.49%). *Figure 23* shows the soil classification map in Nayom watershed, Sta. Cruz, Zambales.

Figure 23 - Soil Classification Map at Nayom Watershed



2.1.3.2 Soil Quality (Sta.Cruz Area – Current ECC) (EISWestChinaMin, 2016)

Table 19 - Soil Quality Result at Sta. Cruz Area

Parameters	Methodology	Results S1	Reporting Limit (mg/kg)
Arsenic, mg/kg	Hydride AAS	0.04	0.02
Cadmium, mg/kg	Flame AAS	ND	0.1
Chromium, mg/kg	Flame AAS	167	0.80
Lead, mg/kg	Flame AAS	ND	0.80
Mercury, mg/kg	AAS- Cold Vapor	ND	0.05
Nickel, mg/kg	Flame AAS	3,590	25
Potassium, mg/kg	Flame AAS	ND	20
Total Nitrogen as TKN	Kjeldahl Titrimetry	2,140	60
Total Phosphate –P	Vanadomolybdophosporic Acid	5,660	200
Total Organic Carbon, %	Titrimetry	2.30	0.01
Total Organic Matter, %	By calculation	3.97	---

ND – Not Detected

From the soil samples collected there are phosphate and nitrogen contents but potassium could not be detected. Presence of Nickel and Chromium were significant in the soil. Organic matter is also found and certain trace level of Arsenic.

2.1.3.3 Methodology (Candelaria Area – Proposed Expansion)

2.1.3.3.1 The Soils of Zambales Literature

Published reports, literatures of the soils, the land use reconnaissance surveys and soils map of Zambales Province (1951), The Soils/Land Resources Evaluation Project (1988), The Physical, Agro-Socio-Economics Environment (Part I, II, and III), were gathered from the Bureau of Soils and Water Management (BSWM). The NAMRIA Topographic Map of the Province of Zambales (1:50,000 Scale) was also used as reference points in order to establish the soil sampling locations of the three (3) parcels of MPSA 316-2010-III, amended I. (i.e. Parcel 2, Parcel 7 and Parcel 8).

2.1.3.3.2 Reconnaissance and Ocular Surveys

The Initial field activity for the soil pedology investigations is a soil reconnaissance and an ocular survey/inspection by the Axceltechs EIA soil pedology study team on May 11, 2018. Another separate field work activities that involved the field assessments of the present land use; establishment of soil sampling sites and; the soil sampling activities were made on May 12, 2018.

The study on soils, agriculture and the present land use covered the review of existing literatures and available maps of the project area.

2.1.3.4 Soil Sampling

2.1.3.4.1 Disturbed Samplings

The special soil Investigations covered the six (6) soil sampling locations within the MPSA 316-2010-III, amended I. Two (2) of the soil sampling sites were made in Parcel 7, three (3) in Parcel 2 and one (1) in Parcel 8

The site selection criteria of the six soil sampling locations namely Soil sampling Location 1 (SS1), Soil sampling Location 2 (SS2), Soil sampling Location 3 (SS3), Soil sampling Location 4 (SS4), Soil sampling Location 5 (SS5) and Soil Sampling Location 6 (SS6) within the MPSA coverage were made in accordance with the present land use, and slope. Their corresponding locations, geographic coordinates and photographs are presented in *Table 20.*

From each soil sampling location, disturbed composite soil samples were collected within the 0 – 30 cm. depth using an ordinary mini trowel. The representative soil samples were randomly collected in a zigzag pattern within the selected sampling sites. There are at least 10 - 15 random soil sampling sites for one composite sample. Presence of organic debris, stone fragments and other unwanted litters were carefully removed from the collected composite samples on site.

Using a cleaned used sacks, each of the six (6) composite samples were manually mixed thoroughly to homogenous the sample and then, quartered twice, rejecting the two (2) quarter portions of the sample. From the remaining 2 quarter approximately Two (2) kilograms of the samples were finally collected per location and kept in a 12” X 16” polyethylene plastic bag and labeled accordingly.

All of the laboratory chemical analyses were done at the CRL Environmental corporation laboratory, Bldg. 2, Berthaphil Compound 1, Berthaphil Inc. Industrial Park, Jose Abad Santos Ave., CFZ Pampanga, submitted on May 13, 2018 for the soil physical and chemical characteristics.

The parameters requested are presented in *Table 21***.** Laboratory results of analyses were reported on June, 2018.

Table 20 - Locations and Coordinates of the Soil Sampling Locations

SS1 (Parcel 7)	**SS2 (Parcel 7)**	**SS3 (Parcel 2)**
Coordinates N 15^0 40’ 18.4” E 119^0 57’ 03”	Coordinates N 15^0 40’ 19.6” E 119^0 58’ 03.8”	Coordinates N 15^0 39’ 07.8” E 119^0 58’ 31.6”
		
SS4 (Parcel 2)	**SS5 (Parcel 8)**	**SS6 (Parcel 2)**
Coordinates N 15^0 39’ 12.3” E 119^0 58’ 24.2”	Coordinates N 15^0 36’ 09.3” E 119^0 59’ 37.0”	Coordinates N 15^0 38’ 00.1” E 119^0 58’ 35.0”
		

Table 21 - Requested Soil Chemical and Physical Analyses WestChinaMin Ferro Nickel Plant and Mining Project, Candelaria Zambales

Chemical Properties
pH (H_2O 1:1)
Available Phosphorus (P, ppm)
Organic Matter (OM, %)
Total Nitrogen (N, ppm)
Electrical Conductivity (EC, µS cm^{-1})
Calcium (Ca, ppm)
Magnesium (Mg, ppm)
Sodium (Na, ppm)
Available Potassium (K, ppm)
Trace Metals/Heavy Metals
Copper Cu(ppm)
Zinc (Zn, ppm)
Mercury (Hg, ppm)
Lead (Pb, ppm)

2.1.3.4.2 Undisturbed Samplings (Soil Erosion Potential of the Project site)

2.1.3.4.2.1 Slake test

Slake test or test for soil friability was done in situ in all of the sampling sites and, is an indicator of soil cohesiveness especially when wet. The soil physical property will determine the soil stability in terms of erosion potentials even when mechanical manipulation is employed (i.e. tillage, excavations). The assessment should be done with dry soil samples and is further explained below:

A soil fragment (at least 1 cm x 1 cm in size) is gently immersed in distilled or rainwater and response to wetting is observed for a period of time (i.e. 10 minutes). The soil is therefore classified in terms of its response to wetting and is described below:

Slake test is not applicable on sandy/stony soils (**Class 0**).

Class 1 = Very unstable. Soil fragment disintegrates in <5 seconds; very fine bubbles may emerge.

Class 2 = Unstable. Soil fragment goes slumping within 5-10 seconds.

Class 3 = Moderately Stable. Slumping of sub-crust but most of the crust is intact.

Class 4 = Very Stable. No slumping of particles is evident after several minutes of being immersed in water; whole fragment remains intact with no swelling; large bubbles may emerge.

Soil correlation with the use of the old Soil Survey reports and maps of Zambales province were used in the identification and delineation of soil types and soil sampling locations. The dominant land use of the six (6) soil sampling locations is presented in *Table 22.*

The impact of the proposed mining project on the soil and vegetation were assessed and the proven effective corresponding mitigation measures from similar ultramafic soils were given.

Table 22 - Dominant Land Use of the Soil Sampling Locations

Dominant Vegetation/Land Use	
P7 SS1 Presence of dense mixed Shrubs and trees species, and grass understory. Presence of small to large stone fragments on the surface. Rolling to undulating terrain.	
P7 SS2 Open grassland, with patches of shrubs species, Dominant vegetation are grasses, with very stony surface with rolling terrain.	

Dominant Vegetation/Land Use	
P2 SS3 Presence of dense shrub species of Bolo Bamboo (*Gagantochloa levis* (Blanco) Merr.), mixed with few shrub and trees species with almost flat to gently undulating terrain.	
P2 SS4 Open grassland mixed with few patches of forest trees and shrub species. Very few stone or rock fragments in the surface. With gently sloping undulating terrain.	
P8 SS5 Very dense open grassland, rolling terrain, presence of Highly fragmented stone fragments in the soil surface	
P2 SS6 Dense mixed open shrubland, with mixed grass understory. Presence of small to large partially weathered rock fragments in the surface soil with rolling terrain.	

2.1.3.5 General Description of the Province of Zambales

Zambales province lies in the western part of Luzon. (approximately between" 14^0 44'36" to 14^0 53'26" north latitude and 119^0 46'02" to 1200 26'08" longitude). It is bounded by Bataan on the south, Pampanga on the south-southeast. Tarlac on the east, Pangasinan on the north-north east and, the west Philippine sea on the west.

Iba, the capital of the province is about 210 kilometers north-northwest of Manila. Traverse from Manila is via the north expressway exiting at the San Fernando Pampanga exit and by way of the Gapan- Olongapo Highway (Route 3). All roads going to all municipalities runs parallel with the coast of West Philippine Sea which is first class and well maintained.

Zambales is a mountainous province. Composed of 13 municipalities and, as per survey, made by the BSWM the province has an aggregate area of 371,169 hectares.

The Zambales Range, known as the Western Cordillera, occupies the whole eastern part of the province. It begins from northern Pangasinan along the eastern part of Zambales to Bataan province on the south. The mountain area has steep slopes, deep ravines, high peaks, rugged ridges and canyons. Bordering the mountain range are hills and table lands. The foothills have rolling to gentle slopes.

The narrow coastal plain is between San Antonio and Palauig with small swamps at many river mouths and from Candelaria to Sta. Cruz to the northern part of Palauig, the hills spurs extend to the sea enclosing in some places small swampy bay-head coastal plains. South of San Antonio, the coast is rough, hilly to mountainous. Some cliff headlands separate small plains which are partly swampy especially in Subic and Olongapo City.

2.1.3.5.1 <u>Environmental Features</u>

The province which lies at the western flank of the Zambales range is characterized by complex physical features. The most recognizable are high mountains, rugged peaks with the steep to very steep slope Zambales range, bordered at the east boundary.

The uncommon vertical faces of the range trending slightly west or north is approximately of 180 km long and 35 km wide. Generally the main crest of the Zambales range is a domal high surface reaching a highest peak of about 2,037 meters. It is bounded by volcanic cone in the southeast portion composing Mt. Pinatubo the second highest peak of t he province with a 1,745 meters. It is particularly located between the boundary of Pampanga, Tarlac and Zambales province. Along the main highways are developed flat to gently sloping plain and valleys where the municipalities are located. The south coast of the province is very irregular with deep and coastal embayment.

The province has many rivers that drain the province. The rivers draining the southern part are Kalaktan, Aninguay, Grullo, Sto. Tomas and Anonang; in the central part are Cabangan, Bucao, Bancal, Bagsit, and Salazar: and in the northern part are Zinay, Lawis, San Vicente, Uacon, Cabatuan and Santa Cruz Rivers. These rivers are swift in steep-sided winding mountain ravines. On the coastal plains they flow on shallow broad channels and wide sandy flood plains and low banks. They cause extensive flood during heavy rains in the mons between June to August and become shallow during the period from October to April.

2.1.3.5.2 Present Land Use

One of the most remarkable surface features observed in the province is its present land use and vegetation. It is rich with forest and sand beaches. As mapped by the BSWM, different land uses of the province were mapped first to determine the crops and vegetation to be planted. However, crops grown in a certain area depend on physical, marketing and other socio-economic factors.

Table 23 - Details of the extent of Different Crops Land Uses and Area Percentage of the Province of Zambales (1988)

Land Use	Area (has)	%
A. Build-up Areas		
Residential/Commercial	3,345	0.9
B. Agricultural Area		
Irrigated paddy rice	11,216	3.02
Non-irrigated paddy rice	23,439	6.32
Upland rice	260	0.07
Corn	554	0.15
Cassava	1,907	0.51
Sweet Potato	3,409	0.92
Citrus	163	0.04

Land Use	Area (has)	%
Mango	1,155	0.31
Cashew	210	0.06
Mixed fruit trees	315	0.09
Coconut	1,766	0.48
C. Grassland		
Open grassland	140,540	37.86
Shrubs	52,464	14.13
Pasture	9,132	2.46
Bamboo	431	0.12
D. Forestland		
Forest/Trees	104,571	28.17
E. Wetland		
Fishpond	1,543	0.41
Mangrove/Nipa	2,957	0.48
Lake	149	0.04
F. Miscellaneous		
Beach sand	1,349	0.36
River wash	10,294	2.77
Total	**371,169**	**100**

Present land use and vegetation as of June, 1987 (i.e. latest land resources appraisal made by the BSWM, *Table 23*) was mapped on a 1: 50,000 topographic map. The present land use was again mapped on a dominant associated scheme wherein the dominant and various associated crops are mapped as a single land use unit and the extent is determined by crop percentage.

2.1.3.5.2.1 Built-up areas

Built up areas of Zambales province are concentrated mainly along the national road and main municipality. These include the residential, industrial and commercial areas. However, other residential areas are also found in agricultural and coastal areas where most of the farmers and fishermen reside. It has an estimated area of 3,345 hectares or 0.90% of the total province area. Most residential areas are associated with fruit trees like mangoes, Jackfruit, chico and coconut.

The biggest commercial and industrial establishments are concentrated in Olongapo City due to the former presence of the Subic Naval Base until the 1990's. There are also mining companies in San Marcelino, Masinloc and Sta. Cruz municipality. Industrialization increased migration of workers thus, there will be a continuous increase in human settlement.

2.1.3.5.2.2 Agricultural areas

These areas include the flat to nearly level alluvial plains, river terrace, foot slopes and shale parent materials in the area is dominantly planted by agricultural crops. About 44, 394 hectares or 12% of the total land area of the province are covered by agricultural crops. The Largest in extent are irrigated and non-irrigated paddy rice, which covers an approximately 34,655 hectares or 78% of the total agricultural areas.

Second largest agricultural crops are because of its sandy to sandy loam soil texture are sweet potato and cassava which cover an approximately 5,316 hectares or 1.43% within the vicinity of Castillejos, San Marcelino and river terraces of San Felipe. Sometimes these crops are intercropped with corn.

Coconut is the most dominant agricultural crop in the area. At present, farmers are starting to plant pineapple as an intercrop to young coconut plantations. This is widely observed near beaches and alluvial plains of the province with approximately 1,766 hectares or 0.48% of the total land area.

In some areas, nearly level to undulating foot slopes and terrain are planted with mixed fruit trees with approximately 1,680 hectares or 0.45% of the total land area. Such fruit trees are mango, cashew, duhat, santol, chico including coconut which sometimes are found in residential areas. Citrus plantation is also observed in Sta. Fe, San Marcelino with an area of 163 hectares. In a small extent, upland rice is also present. Details of the extent of different crops land uses, area percentage is presented in *Table 23.*

2.1.3.5.2.3 Grassland/Shrubland/Pasture land/Bamboo

In the higher uplands, table lands, some hills, rolling and undulating regions, and abandoned river beds where the soils are sandy are to be found the grassland vegetations. This is secured by the Zambales range and hills in the eastern part, grasses are the most predominant vegetation. It occupies an area of about 140,540 hectares or 37.86% of the total province area covering most of the hills and mountain ranges. Most predominant species are cogon (*Imperata cylindrica*) and talahib (*Saccharum spontaneum*).

Shrubs including bamboo have an estimated area of 52,895 hectares or 14% of the total province area. Other shrubs are associated with grasses and forest trees. These are dominantly observed in the hills of Subic and Castillejos.

Kaingeros (slash and Burn farmers) and loggers burn grasses, shrubs including trees yearly just so they could plant their crops. Cut down trees are turned into charcoal for domestic purposes. The slash and burn farmers ultimately abandon the area when farming becomes unsuitable for plant growth.

Existing pasture lands were mapped within the hilly and mountainous area of the province. There are approximately 9,132 hectares or 2.46% of the land area used for pasture. This kind of vegetation in the province is quite extensive.

2.1.3.5.2.4 Forest Land

The forest vegetations are the tropical rain forest, mossy forest, and the secondary forest. The tropical rain forest or primary forest trees cover mostly mountainous and hilly topography of the province particularly areas not yet penetrated by loggers and kaingeros. About 104,571 hectares or 28% of the total province area are covered by forest or wooded area. There are also vines, climbing figs, rattan and wood for commercial purposes.

There is noticeable decrease in forest areas in the province due to kaingin system and illegal logging. It will need an implementation of precautionary measures to conserve the decreased areas of woodland and forest resources.

However, reforestation programs are noted in Candelaria and Sta. Cruz municipalities which is one-way of conserving the watershed and, preventing accelerated erosion.

2.1.3.5.2.5 Wetland

The Mangrove, Nipa and swamp vegetation are found in tide water swamps or river deltas on shores of shallow protected bays, and along river banks and lakes. It is found more extensive in the City of Olongapo, Subic, Masinloc, Candelaria and, Sta. Cruz and cover 4,649 hectares or 0.94% of the province area occupying most of the coastal and low depression areas fringing along the seaboard of the West Philippine Sea.

2.1.3.5.2.6 Miscellaneous

About 11,634 hectares or 3.13% of the total land area are covered by miscellaneous type of landscape. This includes river wash and beach sand. River wash occurs on major rivers draining the province toward the west and the West Philippine Sea and beach sands occur mainly as beach ridges along the shore.

2.1.3.5.2.7 Mineral Land

Soil Survey of the mineral land conducted by the BSWM in the province is normally not included. However, presence of at least 5 mining firms was noted during the survey of its mineral deposit. The five mining companies, four (4) of which are located In Sta. Cruz namely: LNL, LAMI, DMCI, Benguet Consolidated Mines. All of them are extracting Nickel. The BCI/Dizon Mines found in Pili, San Marcelino now is abandoned and undergoing rehabilitation was extracting Copper and Gold.

2.1.3.5.3 Climate

Climate is mean, the sum total of the meteorological phenomena that characterizes the average condition of the atmosphere at any one place on the earth surface. That which we call weather, therefore, is the sum total of its atmospheric conditions (Temperature, pressure, winds, atmosphere and precipitation) for a short period of time. It is a momentary state of the atmosphere. In other words, climate is a composite or generalization of the variety of day to day weather conditions.

Climate is one of the five cardinal factors responsible for soil formation. The influence of climate and vegetation on the characteristics of the soil formed as a result of weathering is felt over broad areas, while the effects of parent material, relief, and age give rise to local differences, as one sees between neighboring fields and farms. Since there are diverse interrelationships among all of these factors in soil formation, one can not say precisely the degree of influence if each of the individual factors. In Some soils the characteristics inherited from the parent materials may be very noticeable, while on other places the long-time influence of climate and vegetation may have erased those differences and very similar soils existing side by side may have developed from quite different rocks. Aside from these natural factors there is the influence of man's use of the soil, which may have changed it, either for better or for worse.

Climate largely determines the type of vegetation that grows naturally in any given region and the methods of agricultural production that must be adopted. It affects to a great degree the success or failure of agriculture in any locality. The productive capacity of the soils and their use-capabilities in one way or another are directly influenced by climate. It affects the industries of the people, health, and land settlement.

Zambales province belongs to the first type of climate. Two distinct seasons, the wet and dry, are well pronounced. The wet season begins from the month of May up to the middle of October, while the dry season starts from the latter part of October and ends in May. June, July, and August are the months of maximum rainfall. The mean annual total rainfall in the area reached to 2,950 mm which ranges from 3,700 to 2200 mm from western to eastern part of the province respectively.

The mean maximum temperature recorded in the area reached to about 31.55^{o}C ranging from 30^{o}C during the months of March, April, and May. The mean minimum temperature is 21.1^{o}C which happens on the months of January, February, and December is the coolest months.

2.1.3.6 The Soils of Zambales Province

2.1.3.6.1 General

The BSWM define a soil series as a group of soils that have the same genetic horizons, similar important morphological characteristics, and similar parent material. It comprises soils having essentially the same general color, structure, consistency, range of relief, natural drainage condition, and other important internal and external characteristics.

In the establishment of a series a geographic name is selected, taken usually from the locality where the soil is first encountered and, identified. For example the Bancal series was first found and classified in the vicinity of Bancal, a barangay in the town of Iba Zambales, Province.

A soil series on the other hand, has one or more soil types, defined according to the texture of the upper part of the soil, or the surface of the soil. The class name such as sand, loamy sand, sandy clay loam, silty clay loam, clay loam or clay is added to the series name to give the complete name of the soil. For example Bancal clay is a soil type within the Bancal series. The soil type therefore, has the same general characteristics as the soil series except for the texture of the surface soil. The Soil type is the principal mapping unit (SMU). Because of its certain specific characteristics, it is usually the unit to which the agronomic data are definitely related.

A phase of a soil type is a variation within the type, differing from the soil type only in some minor features, generally external, that maybe of special practical significance. Differences in relief, stoniness, and extent or degree of erosion are shown as phase. A minor difference in relief may cause a change in agricultural operation or charge in the kind of machinery to be used. The phase of a type with a slight degree of accelerated erosion may need fertilizer requirement and cultural management different from those of the real soil type. A phase of a type due mainly to degree f erosion, degree of slope, and amount of gravel and stone in the surface soil is usually segregated in the soil survey map if the area can be delineated.

A soil complex is a soil association composed of such intimate mixture of series, types, or phases that cannot be indicated separately on a small-scale map. If, in an area, there are several series such as Sara, Sta. Rita, Alimodian and others that are mixed together, the two dominant series must bear the name of the complex as Sara-Sta. Rita complex or Sara-Alimodian complex, as the case maybe.

The soils classified and mapped in Zambales province represent three distinct groups based on their relief as follows: (I) soils of the swamps and marshes, (II) soils of the plains, and (III) soils of the upland hills and mountains. Each soil group was further differentiated based on the mode of formation, profile characteristics and texture of the surface soil. *Table 24* shows the proportionate areas and distribution of the several soil types.

I. SOILS OF THE SWAMPS AND MARSHES

1. Hydrosol (1) - This miscellaneous land type is found in the coastal region bordering the west Philippine Sea. It consists of soils under water throughout the year where mangroves and nipa palms grow. It is found quite extensive in Olongapo city, Masinloc, Candelaria, and Sta. Cruz. It is also found in limited areas in Palauig, Iba, and Subic. The area is 2,750 hectares or 0.75 percent of the total area of the whole province. This kind of land is at present being utilized as salt beds, fishponds, and in growing nipa palms and mangroves.

The soils of the salt beds are generally pale gray to brownish gray sand while those of the swamps and the mangrove areas are a mixture of organic matter, silt and sand.

Agriculturally, the hydrosol of Zambales has no value, for it is unsuited for the cultivation of agricultural crops. It does however, play a part in the economic and social conditions of the people. The salt beds are used for the manufacture of salt, while the fishponds produce Bangos (milkfish) fish that help the people greatly in their monetary needs. Booming is the Cultivation of tiger prawn hatcheries and its commercial propagation. The swamps are planted to nipa palms and mangrove. The nipa palms are made into thatch for roofing purposes, while the mangroves are utilized for timber.

II. SOILS OF THE PLAINS

The soils of the plains include a large portion of the areas along the national highway from Barangay Magujinaya to Subic on both sides of the road to Barangay Pamatawan, southeast of Castillejos to the base of Mt. Mabolinoc, including the lands along the course of the Lawis River towards the base of the mountains and the narrow coastal plains between San Antonio and Palauig. This area is approximately 64,034 hectares or 17.59 percent of the total area of the province.

The soils are classified by the BSWM into five soil series and a miscellaneous land type. These soil series have rather wide range of soil characteristics. The color of the surface soil ranges from pale gray to nearly whitish gray in the case of the Angeles series to light brown, brown, to strong brown for the Quingua, Cabangan, and Bancal series. The surface soil of the foregoing soils is acidic in reaction, although they differ somewhat in the degree of acidity. The pH ranges from 5.72 (medium acid) for the Angeles series to 6.67 (almost neutral) for the Quingua series. The surface soil ranges from silt loam to sand and clay. The soils of these series, however, are the most important agricultural soils of the province and are generally considered the backbone of Zambales agriculture.

The soils of these series have been developed from the geologically recent deposits of various rivers that traverse the plain from the mountain ranges on the eastern part flowing into the West Philippine Sea. These soils which have developed from materials of different periods of deposition exhibit different profile characteristics ranging from slight to moderate profile development. The La Paz and Angeles series are the soils that exhibit slight or no profile development, while the Quingua, Cabangan, and Bancal series of the older alluvial deposits exhibit much more developed profile characteristics.

Table 24 - Area Percentage and Location of Each Soil Type in Zambales Province.

Type Number	***Soil Type***	***Area (Has)***	***Percentage***
1	Hydrosol	2,750	0.75
5	Quingua silt loam	7,767	2.14
26	Antipolo clay	57,721	15.84
45	Mountain soils undifferentiated	177,372	48.66
107	Bani clay	24,219	6.65
118	Beach sands	2,051	0.56
161	Cabangan clay loam	1,958	0.54
162	Cabangan sandy loam	4,465	1.23
163	Bancal clay	5,944	1.63
164	Bulaoen sand clay loam	12,038	3.31
166	Alaminos clay	19,314	5.27
167	Villar sandy loam	4,662	1.27
72	Angeles sand	23,333	6.41
73	Angeles fine sand	13,893	3.82
74	Angeles sandy loam	2,611	0.71
81	La Paz fine sandy loam	4,063	1.11
105	Alaminos sandy loam	397	0.10

1. ANGELES SERIES

The soils of the Angeles series were deposited by various rivers that flow from the eastern mountain ranges to the West Philippine Sea, such as the Pamatuan, Dinomagat, Grullo, Muerto, and Sto. Tomas Rivers. These soils are of recent alluvial deposits having undeveloped profiles. The soils of this series consist of pale gray, brownish gray or ash gray to dark gray when wet. It is gravelly sand, loose and poor in organic matter. The depth ranges from 50 to 55 centimeters from the surface. The substratum is sand with or without gravel and sandstones. The soil has poor water holding capacity but rather high in capillary action.

The topography is level to slightly undulating and moderately rolling. These soils are devoted to the planting of rice, sugarcane, fruit trees, native onion, root crops, vegetables and coconuts. Agojo and Binayoyo trees are also found growing in this area. This series occupies a very wide level area in the towns of Castillejos, San Marcelino, San Antonio, San Felipe and Botolan. The undulating and rolling regions of Botolan in the direction of Villar along Bucao Rivers are included in this area.

Three soil types are classified and mapped under this series.

(a) Angeles sand (72). A typical profile of this series is as follows:

Depth of Soil (cm)	**Angeles Sand Characteristics**
0 – 25	Surface soil - pale gray to ash gray to nearly white when dry and brownish gray to dark gray when wet. It is sand to coarse sand mixed with some fine sandy loam materials which re dust-like when dry. Loose and structure less. It ranges in depth from 20 to 25 centimeters.
25 – 55	Subsoil - gray to pale gray to ash gray when dry and brownish gray to dark when wet. It is loam, gravelly sand and poor in organic matter. The depth ranges from 50 to 55 centimeters from the surface.
55 and below	Substratum - coarse sand to gravelly sand of brownish gray to ash gray.

This soil type represents the largest area mapped under this series. It covers almost half of San Marcelino, part of San Antonio, San Narciso, San Felipe and part of Botolan. It has an area of 23, 333 hectares or 6.41 percent of the total area of the province. The land is level to slightly undulating and moderately rolling. Almost one half of these areas in San Marcelino and Botolan are uncultivated. This is so because almost every year the rivers overflow their banks and crops grown are washed away.

In the areas cultivated most important crop grown is rice but the yields are very poor even when fertilizer is applied. The absence of irrigation in most agricultural areas together with the loose and sandy nature of this soil type account for the low production of rice. Sweet potato, cassava, watermelon, corn and vegetables are also grown in this soil type.

(b) Angeles Fine Sand (73). – This is the second largest soil type mapped and classified under the Angeles series. The area is 13,893 hectares or 3.82 percent. It is found in the municipalities of Castillejos, San Antonio, San Narciso, San Felipe, and Botolan. A small area is also found in San Marcelino. The surface soil which ranges in depth from 20 – 25 centimeters is pale gray to ash gray, loose and structure less fine sand. It contains considerable amount of organic matter. The subsoil to a depth of 60 centimeters from the surface is gray to pale gray, loose and gravelly, with less organic matter. Below this horizon to a depth of 70 centimeters from the surface is t he substratum. The texture is coarse sand to gravelly sand and is brownish gray when wet to almost white when dry.

Angeles fine sand is the most important soil type in the series. The topography is very nearly level to slightly undulating and is principally devoted to the cultivation of lowland rice. However, corn, sugarcane, native onions, vegetables and root crops. Such as cassava, sweet potato and peanut are also grown. The soil has a good external and internal drainage.

(c) Angeles Sandy Loam (74). - This soil type is found mostly in the municipality of San Marcelino. A small portion is located in Castillejos and San Antonio. This type has an area of 2,611 hectares or 0.71 percent. The surface soil is loose. The average depth is from 15 to 20 centimeters. The soil when dry is gray but becomes dark brown to grayish brown when wet. It is easily plowed at its optimum moisture condition. The area is level to slightly undulating, with rice as the principal crop grown. Other cash crops like corn, sugarcane, sweet potato, peanuts and miscellaneous vegetables are also planted.

Secondary crops like corn, onions, taro, sweet potato, and beans are planted in small lots ranging in area from one-half to two thirds of a hectare.

2. LA PAZ SERIES

La Paz series was first established and mapped in Tarlac Province. As found in Zambales, this series, like the Angeles series is traversed by several rivers such as the Dimamagat, Dirita, Grullo, Muerto, Uacon and Sta. Cruz Rivers.
The soils of La Paz series consist of brownish gray, ash gray, structureless and loose to nearly compact silt loam to fine sandy loam surface soil. The subsoil is fine to medium sand while the substratum is brownish gray to yellowish gray coarse sand. Unlike that of the Angeles series, the subsoil and substratum of this series have no gravel. The external drainage is fair to excessive.

The topography is level to slightly rolling. The elevated areas are planted to sugarcane, vegetables, fruit trees, corn, sweet potato, peanuts, cassava, beans and upland rice. The lower areas are devoted mainly to the cultivation of lowland rice, corn, beans and mungbean as secondary crops.

The La Paz fine sandy loam is the only type delineated under this series.

(a). La Paz Fine Sandy Loam (81). – A typical profile of this soil type is as follows:

Depth of Soil (cm)	**La Paz Fine Sandy Loam Characteristics**
0 – 20	Surface soil - light brown, yellowish brown silt loam to fine sandy loam. Plenty of red to chocolate brown streaks in the lower surface soil. It is fine granular and moderately friable, slightly loose and porous. Boundaries between horizons are clear and smooth.
20 – 45	Subsoil, light brown, loose and slightly friable, heavier than the surface soil, poor in organic matter.
45 – 74	Light brown, loose. Porous and friable fine sandy loam to fine sand with no gravel.
74 - below	Grayish brown in color, medium sand to coarse sand, loose and porous substratum.

This soil type is found in the municipalities of San Antonio, San Narciso, and part of San Felipe along the national highway. It is also found in the municipalities of Palauig, Masinloc, Candelaria, and Sta. Cruz. The area is mostly level and is grown mainly to lowland rice. Where the land is slightly elevated it is grown to upland rice, root crops, corn, and other secondary crops. This soil type is 4,063 hectares or 1.11 percent of the total soil cover.

3. QUINGUA SERIES

The Quingua series was first established and mapped in Bulacan province. In Zambales Province this is found in the municipalities of Olongapo, Subic, Castillejos and Candelaria. This series is devoted mostly to the cultivation of lowland rice.

The soil consist of light brown, yellowish brown to brown silt loam to fine sandy loam surface soil with abundant red to chocolate brown streaks. It is loose and somewhat porous. The subsoil is light brown, heavier in texture than the surface soil, slightly compact silty clay loam to clay. In some places the subsoil is loose and quite friable, but in the majority of cases it is slightly compact. Below 75 centimeters is the brownish yellow to brown substratum whose texture ranges from fine sandy loam, silt loam to silty clay loam. In some portions the substratum is fine sandy loam to sand.

The topography is level to slightly undulating. The undulating portions are not generally cultivated and the common vegetation are either grass or shrubs of different species. Where the area is cultivated it is generally planted to sugarcane, vegetables, upland rice and fruit trees. The level portions are planted to lowland rice. Fruit trees such as cashew, mangoes, caimitos, avocados, and oranges are also grown on this type. Quingua silt loam is the only soil type delineated under this series in Zambales Province.

(a). Quingua silt loam (5). - A typical profile of this type is as follows:

Depth of Soil (cm)	**Quingua Silt Loam Characteristics**
0 – 20	Surface soil - Light brown, yellowish brown to brown silt loam to fine sandy loam surface soil with abundant red to chocolate brown streaks. It is loose and fine granular and easily worked at optimum moisture. Boundary of layers between the horizons is clear and smooth.
20 – 45	Subsoil - light brown, loose to slightly compact, heavier in texture than the surface soil, friable silty clay loam. The presence of

	heavier material is due to the leaching of the fine materials of the surface soil.
45 - 74	Light brown, loose and friable fine sandy loam to fine sand lower subsoil.
74 – and below	Substratum, sand to coarse sand brownish yellow to brown.

This soil type is one of the highly priced agricultural lands in the province. It is devoted principally to lowland rice culture. It has an area of 7,767 hectares or 2.14 percent of the total area of the province. Except in places near the rivers and creeks, this type is generally not irrigated, and the crop depends on the rain water during its growing period. Sugarcane, corn, and vegetables are the secondary crops planted in small patches. Areas near the rivers or creeks where there is water available even during the dry season are planted to mungbean, beans and peanut. Fruit trees such as caimito, cashew, orange, and mango are also grown on this type.

4. CABANGAN SERIES

Cabangan series is a new series established and mapped in the province. The soils consist of pale brown to grayish brown clay loam to silty clay loam surface soil with a depth of from 15 to 25 centimeters. The lowland rice fields have plenty of reddish to yellowish red streaks. When the surface is silty clay loam it is fine granular and when it is clay loam, it is friable at optimum moisture, sticky and quite plastic when wet. When dry it becomes hard and brittle. It is quite loose to slightly compact. The subsoil is pale brown to brown to light brown, quite compact and coarser in texture than the surface soil. Below 74 centimeters is brown to dark brown silty clay grading to clay to sandy clay substratum. This series belongs to the older alluvial soils having moderately developed profile.

The topography is level to slightly undulating and very moderately rolling. The most important crop grown is rice. The moderately rolling areas are planted to upland rice, corn, sugar cane, fruit trees, coconuts, vegetables, and root crops.

There are two soil types classified under this series, with Cabangan clay loam it represents the typical profile characteristics.

(a). Cabangan clay Loam (161). – This type is found in the towns of Cabangan, San Felipe, Botolan, and Masinloc. It covers an area of 1,958 hectares or 0.54 percent of the total soil cover of the province. The land is level to slightly undulating. Most of the areas are planted to lowland rice.

Corn, sugar cane, and root crops are the secondary crops planted in small patches. A typical profile of this type is as follows:

Depth of Soil (cm)	Cabangan Clay Loam Characteristics
0 -25	Surface soil - pale brown to brown to grayish brown silty clay loam to clay loam, Loose to slightly compact, and contain plenty of reddish to yellowish red streaks. When the surface soil is silty clay loam it is granular and when clay loam it is friable at optimum moisture, sticky and quite plastic when wet, becomes hard and brittle when dry. Easy to plow at optimum moisture condition. Boundaries of horizon are clear and smooth.
25 – 55	Subsoil - is pale brown to brown to light brown, slightly compact and heavier than the above horizons, but friable.
55 – 70	Brown to grayish brown, coarser the above horizons and containing some traces of weathered shales.
70 – and below	Brown to dark brown, sandy loam to sandy clay loam. In other places, this horizon is dark brown clay and used by the farmers in the manufacture of earthen pots.

Lowland rice is the principal crop raised on this soil. While this type of soil is of average fertility, it is imperative to follow the good agricultural practices (GAP) of soil management in order that the soil fertility can be maintained.

(b) Cabangan sandy loam (162). - Cabangan sandy loam is the other soil type classified and mapped under this series. It covers an area of 4,465 hectares representing 1.25 percent of the total soil cover of the province. It is found in the towns of San Felipe, and Cabangan. The topography is level to moderately rolling. The surface soil has a depth of from 15 to 20 centimeters, brown to pale brown to grayish brown, sandy loam to fine sand, loose and granular. The subsoil is pale brown to light brown, slightly compact and heavier in texture than the above horizons, containing some traces of weathered shales. The substratum is dark brown grading from silty clay to sandy clay. The level portions of this soil type, especially those located at Cabangan town, are cultivated to lowland rice. The slightly elevated portion is planted to upland rice, root crops, bananas, and fruit trees. A wide portion of this type is open grassland area. Parts of it are covered with guava trees, shrubs and secondary forest.

5. BANCAL SERIES

Bancal series is another new series established and mapped in Zambales. Like the Cabangan series, it belongs to the older alluvial plains of the province having a moderately developed profile and is generally a deep soil. The soil consists of light brown, brown to strong brown sandy clay loam to clay surface soil, consistency is loose and friable. In a well drained area, the color of the surface is light brown to almost black, compact clay loam to clay. It is sticky and plastic when wet but, it is hard and cracks readily when subjected to drying. Below 80 centimeters is a substratum whose color is light gray to medium gray. It is gritty and slightly friable when dry but, somewhat sticky when wet.

The topographic feature is level to slightly undulating. Rice is the principal crop grown on this type. Other crops like sugar cane, peanuts, sweet potato, cassava, vegetables and mango, caimito, avocado, and oranges are also grown. There is only one soil type classified and delineated under this series.

(a) Bancal Clay (163). – The profile characteristics of this soil type are as follows:

Depth of Soil (cm)	Bancal Clay Characteristics
0 -25	Surface soil - Light brown to strong brown sandy clay loam to clay, slightly porous and friable surface soil. In the undisturbed and under dry condition the soil is almost compact and cracks into big clods. When plowed and harrowed with optimum moisture content, this soil type produces a good tilth, making a very fine mulch during dry season. The boundaries of the horizons are clear and smooth.
25 – 55	Subsoil - brown to dark brown and almost black in some areas, compact, sticky and plastic when wet, and hard when dry, clay loam to clay.
55 – 80	Same as above except that the color is light brown with chocolate red and grayish brown streaks in the lower subsoil.

80 – below	Substratum - is light gray to medium gray, gritty, slightly compact, and friable sandy clay loam. When wet it is quite plastic and somewhat sticky, but when dry it becomes hard. In majority of cases the substratum is sandy loam to sandy clay loam and in some places, it is sandy clay loam to sandy clay.

This soil type covers an area of 5,994 hectares representing 1.63 percent of the total area of the province. It is found in the towns of Iba and Palauig. Almost all the level and lowland areas of Iba and a portion of the lowland on the southern part of Palauig are mapped under this type. This soil belongs to the older alluvial deposits. The principal crop grown is rice with sugar cane, fruit trees, vegetables, root crops and corn as secondary crops. In some part of Iba, rice is rotated with mungbean and beans. The rest of the fields after the rice is harvested is left open for pastures. Sometimes some of these fields are left open for pastures.

In some of the elevated portions are planted with sugar cane, pineapple, cassava, corn, sweet potato and early upland rice varieties.

6. MISCELLANEOUS LAND TYPES

(a) Beach sand (118). - This land type is included under the soil of the plain. This is made up of the sandy areas bordering the West Philippine Sea and forming a narrow coastal plain between San Antonio and Candelaria. The sand is usually grayish brown. In some places like Botolan, San Narciso, San Felipe and Candelaria, part of the beach sand area is planted extensively to coconut. The total area is 2,051 hectares which is 0.57 percent of the total area of the province.

III. SOILS OF THE UPLANDS, HILLS AND MOUNTAINS

The soils of the upland, hills and mountains are generally referred to lands lying above the stream terraces, far from the accumulation of any alluvial deposits.

They represent an aggregate area of 295,723 hectares or 81.10 percent of the total area of the province. These soils are classified and mapped into five soil series and a miscellaneous land type. The latter, which is represented by the mountain soils undifferentiated, with an area of 177,372 hectares or 48.66 percent of the total area of the province, is comparatively of no agricultural value, because it is inherently unfavorable to tillage operations.

These soils have developed from a highly weathered chalk-like sandy shale material which makes up the Villar series, hard igneous bedrock which represents the Antipolo and Alaminos series, and the unconsolidated sedimentary rock which include the Bani and Bulaoen series. All soils included in this area have been eroded and heavily leached. The pH ranges from 5.13 for the Antipolo series which is strongly acid to 6.32 for the Bani series which is slightly acidic. All of these soils, however, exhibit moderate to fairly well developed profile characteristics.

1. ANTIPOLO SERIES

This soil series is the continuation of the Antipolo series mapped in Bataan. It was, however, first identified, established and mapped in the province of Rizal. Antipolo series is reddish brown to red to almost brick red in color, very friable surface soil that has developed from igneous or volcanic mountain rocks. The upper subsoil is composed of highly weathered igneous rock boulders and stones. The lower part of the subsoil is lined with partly weathered igneous volcanic rocks mostly basalt, gabbro and, andesites. Antipolo clay is the lone soil type mapped in the province. The effects of exfoliation rocks are visible in road -cuts in Subic, Olongapo, the boundary of Bataan and Zambales and between San Felipe and Cabangan.

The topographic feature of this series is rolling to hilly and mountainous. The rolling areas are planted to upland rice, vegetables and some fruit trees. The hills and mountains are covered either with secondary or primary forest with open grasslands in some portions. Some of the hill slopes in San Felipe and Cabangan are planted to maguey which shows a fairly good growth.

(a) Antipolo clay (26). – This soil type covers an area of 57,721 hectares which includes the hills and mountains of Cabangan, San Felipe, San Antonio, Subic, Castillejos and Olongapo and the rolling areas, hills and mountains between Olongapo and Bataan Province. It is not important agriculturally, being hilly and mountainous. Erosion on bare areas have advanced considerably forming big gullies. The rolling areas are utilized for the upland rice, corn, and vegetables. Fruit trees such as mangoes, caimitos, avocados, etc., are also grown. The regions along the borders of the Bataan-Zambales zigzag road are being reforested and planted to Narra and other allied forest trees. Some of the hill slopes in San Felipe and Cabangan are planted to Maguey.

2. VILLAR SERIES

The Villar series is new series established, classified and mapped in Zambales Province. It belongs to the soils on older plains or terraces, having hardpan subsoil or lower subsoil layers. The surface soils of this series consist of brown to light brown when dry and dark grayish brown to almost black when wet, loose and fine granular sandy loam to silt loam with fair amount of organic matter. The subsoil is composed of three horizons. The upper horizon is whitish to grayish-white brown, highly weathered chalk –like sandy shale material and easily pulverized even with fingers. The middle subsoil horizon is highly weathered sandstone, grayish brown, granular, loose with reddish brown streaks. The lower horizon is a layer of soils whose texture, color, and structure is the same as those of the surface soil. Below 120 centimeters to an indefinite depth is apparently the parent material or substratum. It is a mixture of coarse sand and gravel, grayish to whitish gray in color, very loose, structure less and with occasional accumulation of sandstone boulders.

The topographic feature of this series is level tableland or plateau to slightly undulating and rolling. The external drainage is good to excessive. In some places, erosion is serious on coconut of the absence of the necessary vegetative cover. In most cases the surface soil had been washed away exposing the subsoil, and the substratum on the surface.

The rolling area is very thinly forested, while the level and undulating areas are found covered with grass, binayoyo, cogon, guavas and shrubs of different species. The open cultivated area is planted to corn, upland rice, sweet potato, cassava, oranges, mangoes, avocados, and coconuts. This series includes a soil type, the Villar sandy loam.

(a) Villar sandy loam (167). – This soil type is found in the upper part of Botolan, between Balin-Baquero and Bucao Rivers, starting from Poon Bato to Villar proper. It occupies an area of 4,662 hectares or 1.27 percent of the total soil cover of the province. The profile characteristics of this type are as follows:

Depth of Soil (cm)	**Villar Sandy Loam Characteristics**
0 -30	Surface soil - gray to dark gray when dry and dark gray to almost black when wet, loose and fine granular sandy loam to silt loam. With plenty of organic matter. Boundaries between horizons are clear and smooth.
30 – 45	Highly weathered chalk-like sandy material, almost white in color, easily pulverized with fingers. This is the upper layer of the subsoil.
45 – 65	Highly weathered sandstone, loose, porous, and granular, whitish gray in color with reddish streaks, middle layer of subsoil.

65 – 120	The same as the surface soil in color, texture and structure. Lower subsoil.
120 – below	Indefinite depth of weathered sandstone, whitish gray in color with reddish streaks, porous, very loose and granular. Sandstone boulders are scattered and lined in this horizon.

A greater part of this type is flat and level. The surface soil has a depth of from 15 to 30 centimeters and is easily worked. Upland rice, sugar cane, corn, vegetables, and root crops, such as cassava, peanuts and sweet potato were previously planted in this area. Some portions of the area when properly diked, like those of lowland rice fields in Central Luzon, will invariably suited to the cultivation of lowland rice. The rolling area can best be utilized for growing fruit trees and for pasture purposes.

3. BULAOEN SERIES

The Bulaoen series, like the Villar series, is a new soil series mapped and classified in the province of Zambales. It belongs to the group of soils considered under the brown to grayish brown soils of the tropics. The surface soil is light reddish brown, brown to grayish brown, porous, loose and fine granular sandy loam to silt loam. The subsoil is reddish brown to light reddish brown, heavier in texture than the surface soil and with plenty of highly weathered gravels and few iron concretions that make it rather hard to bore with a soil auger. Below this horizon is a zone of light clay loam to clay, friable, massive and sticky. The color is brown, strong brown to light reddish brown with few concretions. In this horizon are found scattered gabbro rocks.

The topographic feature is from flay upland to undulating and rolling with small patches of lowland in depressed areas. In the undulating and rolling and rolling areas, outcrops of gabbro rocks and boulders are exposed on the surface. The rolling and hilly areas are thinly forested and when open are grown to grass and cogon. The level and undulating areas are covered with cogon grass, shrubs, binayoyo trees, boho and bamboo. The open cultivated areas are grown to upland rice, lowland rice, corn, and vegetables. External drainage is excessive. This series includes only one soil type, the Bulaoen sandy clay loam.

(a) Bulaoen sandy clay loam (164). - This soil type occupies an area of 12, 038 hectares or 3.31 percent of the total area of the province. Part of the rolling and undulating area on the eastern part of Iba, the flat upland, rolling and hilly regions on the eastern part of Palauig are classified under this type. A characteristic profile of this type is as follows:

Depth of Soil (cm)	Bulaoen Sandy Clay Loam Characteristics
0 -30	Surface soil, brown to dark grayish brown when dry, assumes a black color when wet, loose and fine granular. In some places the color is strong brown, contains plenty of organic matter in an undisturbed place. Boundaries between horizons are wavy and smooth.
30 – 60	Brown to light reddish brown clay loam with plenty of weathered gravels and iron concretions that make the soil auger hardly go through this horizon when boring. In some regions where erosion is serious, these weathered gravels and concretions are exposed and also boulders of gabbro rocks are on top of the surface soil.
60 – below	Brown to strong brown to reddish brown, clay loam, massive and friable. When the soil is wet it is sticky. In this horizon are scattered gabbro rocks.

This type is one of the most extensive soils in Palauig. In the higher elevations, especially in steeper slopes, the soils are shallower than those of the gentler ones and the flat uplands or plateaus.

External and internal drainage are good to excessive. Because of the physical characteristics and the nature of the relief, this soil is susceptible to erosion. In places where the vegetation is greatly disturbed, the soil is subject to intense erosion, consequently weathered gravels and concretions as well as rocks are exposed on the surface. Only small areas in between hills are cultivated for lowland rice. Upland rice, corn and vegetable are the other crops planted.

4. BANI SERIES

Bani series was first established and mapped in Pangasinan Province. These soils have been developed from the underlying stratified rocks of limestones, sandstones, and shales. The surface soil of this series in a poorly drained area, is dark gray to nearly black. In well drained portions, the color is pale gray to light brownish gray, friable, coarse and fragmental loam to clay loam. When wet it is sticky. The subsoil is light-brownish gray loam to sandy loam, waxy when seemingly wet and sticky when very wet. The substratum is a highly weathered chalklike tuffaceous material.

In this stratified tuffaceous rock parent material from which the soil developed are found some lime rock boulders scattered throughout the horizon.

The topography is rolling upland, hilly and mountainous. There are lowland areas between the hills which are devoted to growing of lowland rice. The hilly regions are forested while the rolling uplands are open grassland areas.

In Zambales Province only one soil type, the Bani clay, was classified and mapped under this soil series.

(a) Bani clay (107). – This soil type is one of the most extensive soils of the province of Zambales. It has an area of 24,219 hectares and occupies that part of the rolling upland of Palauig, Masinloc, Candelaria, and Sta. Cruz. A typical profile of this type as mapped in the province is as follows:

Depth of Soil (cm)	Bani Clay Characteristics
0 -35	Surface soil, dark to nearly black in poorly drained areas and pale brown to light brownish gray in well drained areas, friable, coarse and fragmental clay loam to clay. When wet it is sticky. Boundaries between horizons are clear and smooth.
35 – 65	Light brownish gray, cloddy with sharp ocular shape clay loam to sandy loam. Waxy when seemingly wet, sticky when very wet.
65 – 90	Highly weathered whitish chalk like tuffaceous material. Reddish brown soil along the sides of crevices.
90 – 152	Soft chalk like tuffaceous stone material with yellowish red soil along the sides of crevices, apparently parent material of the soil.

The soils of the lowland and level areas devoted to rice are older alluvial deposits. It is dark gray to almost black in color with a depth varying from 25 to 30 centimeters. When the soil becomes very dry it forms cracks to as deep as 45 centimeters, but when wet, it is quite sticky and plastic. The external and internal drainage is poor, the soil being devoted to lowland rice culture.

In the upper areas, those of the rolling and hilly portions, the depth of the surface soil varies from 0 to 20 centimeters, depending upon the degree of erosion that has taken place. The soil is pale brown to light brown, friable, coarse fragmental clay loam to clay. The external drainage is good but the internal drainage is good but the internal drainage is fair. This area is devoted to pastures but in some isolated places, upland rice, corn and other minor crops are planted. Fruit trees, like mangoes, cashew, santol, oranges and caimitos are also planted.

5. ALAMINOS SERIES

This series is the continuation of the alaminos series established in Pangasinan Province. This soil, like the Antipolo and Bulaoen series belongs to the tropical red soils found generally in regions of tropical rain forest climate or other tropical forest regions. Alaminos series differs from the Antipolo and Bulaoen series which are also found in Zambales in that it has a deep soil of the same horizon characteristics from the surface down to a depth of three or more meters. Where it is typically developed it consists of yellowish brown to orange brown, reddish brown and red in color with no distinct horizon differentiation from the surface down to the substratum. The surface soil is quite loose, porous, friable, powdery, and fine granular to almost structure less. The profile when exposed for several days exhibit a cloddy to nearly fine columnar structure. It is sticky when wet but dries so quickly that plowing is possible within a few hours after a heavy rain. In cultivated areas along the hillsides and foothills, the soil dries to a depth of 50 to 80 centimeters or more, and becomes hard and compact making boring with an auger difficult.

In places where erosion is serious, rock outcrops are also found in the surface. Some highly weathered rocks are also found in the surface. Boulders of basalt, diorite, andesite, conglumerates and serpentine rocks are present in this series.

The topography is from slightly rolling to hilly and mountainous. The mountainous and hilly regions are dissected by deep ravines and gullies and are either covered with shrubs or secondary forest. The rolling areas have a “Parang”type of vegetation; mostly found growing are duhat, guava, binayoyo and alibangbang trees. The area is highly mineralized. Chromite is the principal mineral found. For agricultural purposes, however, this soil type has less value, being hilly and mountainous.

Under this series two soil types were established, namely, Alaminos sandy loam and Alaminos clay.

(a) Alaminos sandy loam (105). – As found and mapped in Zambales Province, the Alaminos sandy loam occurs on the northern part of Sta. Cruz along the Zambales-Pangasinan boundary.

This type covers an area of 397 hectares or 0.10 percent of the total area of the province. The topography is slightly undulating to rolling and the area is principally devoted to the cultivation of coconut, corn, sweet potato, cassava and upland rice. The surface soil is light reddish brown, loose, friable sandy loam ranging in depth from 20 to 30 centimeters. Below this horizon is a reddish brown loam, underlain by poor-grade limestone rocks mixed with highly weathered basalts and chalk-white tuffaceous rock. Apparently this inter-bedded layer of rocks must have been the parent material of this soil.

(b) Alaminos clay (166). – This type occupies the rolling hilly and mountainous portions east of Candelaria and that portion of Sta. Cruz towards the Acoje Mining Company. It has an area of 19,314 hectares. A typical profile characteristic of this soil type is as follows:

Depth of Soil (cm)	Alaminos Clay Characteristics
0 – 35	Strong brown color soils, varying in shade from chocolate brown, reddish brown, red, orange and reddish yellowish-brown color, depending upon the amount of moisture, organic matter content, and the extent of weathering of parent material. The soils of deforested areas have lighter color varying from orange to reddish brown, columnar, porous loose silt loam to clay loam. Sticky when wet and friable when dry.
35 – 70	The lower horizon is more reddish brown to almost brick in color. The soil when dry exhibits a cloddy to nearly coarse granular structure with almost uniform physical characteristics from the surface down to the underlying parent materials.
70 – below	The physical characteristics remains the same as surface soil but the amount of gravel and iron concretions varies with the depth. There are sometimes limestones, basalts and conglomerates.

Agriculturally, this soil type is less important as the relief is generally rugged for ordinary agricultural purpose.

6. MISCELLANEOUS LAND TYPES

(a) Mountain soils undifferentiated (45). - The soils of this type are called mountain soils, undifferentiated, because of their relative geographical location, that is, inaccessibility to survey party. These are the Zambales mountain ranges along the eastern part of the province having deep ravines, and canyons with high peaks and rugged ridges. The mountains north of Subic Bay to the town of San Antonio are included in this land type. Some parts of this mountain area are bare. They have no agricultural value, but are rich in mineral and forest resources. There are five mining companies in these mountains especially in Masinloc, Candelaria and Sta. Cruz are in operation for sometime but, recently ordered by the Department of Environment and Natural Resources (DENR) to shut down their operation due to environmental concerns.

2.1.3.7 Morphology of Zambales Soils

Soils are mixtures of fragmented and partly or wholly weathered rock and minerals, organic matter, water and air, in greatly varying proportions, and have more or less distinct layers of horizons developed under the influence of climate and living organisms. They are the products of interaction of the different factors of soil formation acting upon the parent material that have continued through ages. The principal factors of soil formation are (1) parent material. (2) climate, (3) living organisms, both plant and animals, (4) relief or physiography of the land, and (5) time, the length of time these factors of soil development acted on the materials. The age of development and characteristics of the soil profile depend upon which factors or combination of factors exerts more influence over the other. Thus, three groups of soils are readily recognized: (1) Soils having well developed soil profile characteristics. These conditions are found where the influence of the active factors of climate and living organisms, chiefly vegetation, is dominant over relief, parent material and age. These characteristics are best developed on the gently undulating and moderately rolling areas but not perfectly level upland with good drainage. (2) Soils having more or less, well developed soil profile characteristics that reflect material over the normal effect of climate and vegetation. (3) Soils without well developed soil profile characteristics either because of their youth or because of the different factors have no marked influence over the other on the soil.

The soils of the Philippines in general classification of the soils of the world belong to the soil group known as the red and yellow soils of the Tropics. These groups of soils are either mature or immature, with or without true soil profiles. They are the product of the dominance of climate and biologic factors over the relief, parent material and time. The islands though in the tropical zone have four distinct types of rainfall distribution which exert a great influence on soil formation. The various relief and drainage conditions give rise to the age variation and characteristics of the soil profile. There are young soils of comparatively recent deposits of alluvial materials, and oil or matures soils with some accumulation of limestone precipitates and colloidal material in the subsoil or in the substratum. The younger soils are found in the plains, valleys and alluvial fans. The semi matured soils are in the higher terraces, while the matured soils are located in plateaus, table lands, and mountain areas. The Philippine soils based on topography, mode and formation, and kinds of profile have nine (9) profile groups. Under this grouping, the soils of the province of Zambales are arranged as follows:

Profile group I –

.1 Coastal beach sand

Profile group II –

.1 Angeles series

.2 La Paz series

Profile group III –

.1 Quingua series

.2 Cabangan series

.3 Bancal series

Profile group V –

.1 Villar series

Profile group VII

.1 Bulaoen series

.2 Antipolo series

.3 Alaminos series

Profile group VIII –

.1 Bani series

Profile group I is made of soils of recent alluvial fans, flood plains or other secondary deposits having undeveloped profiles underlain by unconsolidated materials. Under this group is the coastal beach sand, a soil of recent deposition with underdeveloped profile. The beach sand is composed of layers of fine to coarse structureless sand.

The soils of profile group II are represented by the Angeles and La Paz series, which are young alluvial fans, flood plains or other secondary deposits having slightly developed profiles and underlain by unconsolidated materials. These soils were first found and mapped in Pampanga Province. They differ in the color and thickness of their surface and the presence or absence of gravels in their subsoils and substratum. The Angeles series has gravels in the subsoil and substratum which are absent in the La Paz series.

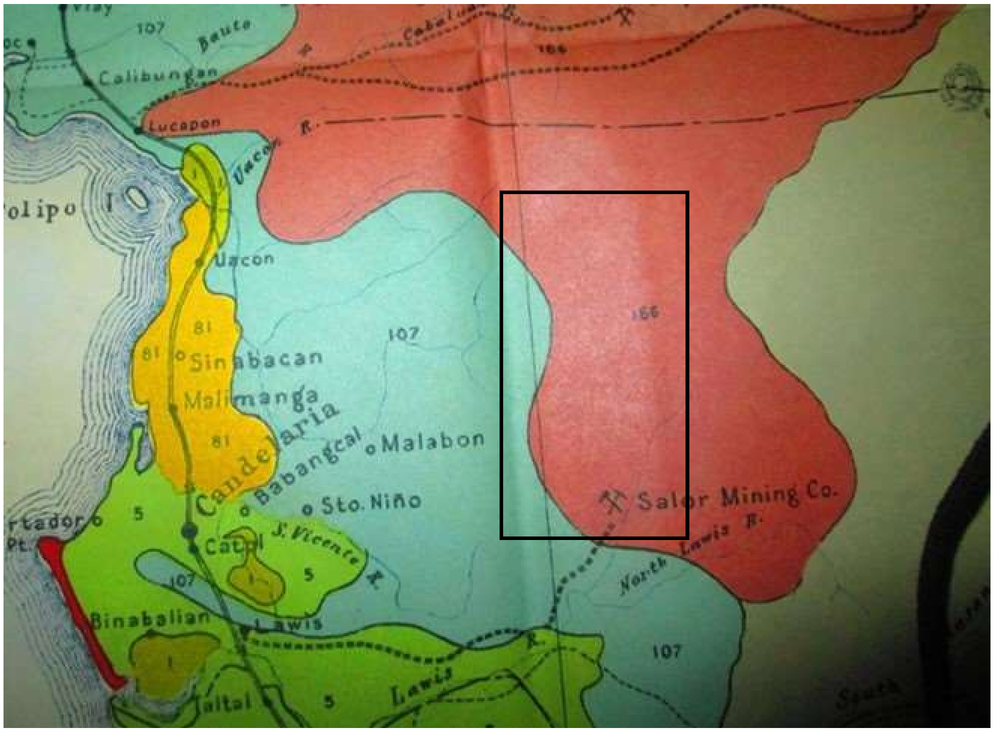
The Quingua, Cabangan, and Bancal series belong to Profile group III. These are the soils representing the older alluvial fans, alluvial plain or terraces having moderately developed profiles (moderately dense subsoil) underlain by unconsolidated material. These are generally deep soils and are not underlain by claypan or hardpan, but whose subsoils are moderately dense. The Quingua series was first established in Bulacan province. While the Cabangan and Bancal series are newly identified and were mapped in Zambales province. Although these soils are classified under the same soil profile group, they differ from each other in their soil profile characteristics as to color, depth of horizons, and the texture and structure of the subsoils. The color of the surface soil of Bancal series is from brown to light brown to strong brown, while that of Cabangan series is pale brown to grayish brown. The Quingua series, on the other hand, has a light brown, yellowish brown to brown surface soil. The subsoil of the Bancal series has a depth of from 50 to 60 centimeters, clay loam to clay, moderately compact to compact, sticky and plastic when wet. The Cabangan series has a subsoil of from 50 to 55 centimeters deep, coarser silt loam to silty clay loam and friable with traces of weathered shales. The Quingua series has silty clay loam to loam subsoil and a depth of from 45 to 54 centimeters.

The soil of the Villar series is under Profile group V. Soils under this group belong to the older plains or terraces, having hard pan or lower subsoil layers generally underlain by unconsolidated material. These soils have cemented rocklike hardpan horizons that do not soften with water. The Villar series has a highly weathered chalklike sandy shale material, whitish in color and does not soften with water. The parent material of this series is weathered sandstone. It is developed under topography of table-land or plateau. The external drainage is poor due to hardpan subsoil.

The soils of Antipolo, Bulaoen, and Alaminos series fall under the Profile group VII which are soils on the upland areas developed from underlying igneous rock and occupying a rolling to steep topography. They are primary soils as a result of rock weathering. They belong to the red soils or lateritic soils of the Tropics. The reddish-brown color of these soils is due to the un-hydrated oxides of iron. The deep red color found in some places is attributed to good drainage.

The Bani series was first classified in Pangasinan province It belongs to the soils on upland areas developed on consolidated sedimentary rocks. It is one of those soils formed on stratified rocks such as limestones, sandstones, and shales. The topography is generally rolling to rough rolling. Bani series is under Profile group VIII.

2.1.4 Soils of the Project Area



Source: (BSWM)

Figure 24 - Soil Map of the Project area (Municipality Candelaria), Province of Zambales Indicating Soil Series Numbers.

Soils are mixtures of fragmented and partly or wholly weathered rock and minerals, organic matter, water, and air, in greatly varying proportions, and have more or less distinct layers or horizons developed under the influence of climate action of the different factors of soil formation acting upon the parent material that have continued through ages.

Figure 24 shows portion of the original Soil Map of the Project area within the Municipality of Candelaria province of Zambales. Based on the soil survey and assessment conducted (in black color outline), the project area belongs to the Alaminos Clay (166). This type occupies the rolling hilly and mountainous portions east of Candelaria and that portion of Sta. Cruz toward the Acoje Mining Company. It has an area of 19,314 hectares.

2.1.4.1 Soil Chemical Properties of Soil Sampling Locations

2.1.4.1.1 Soil pH

Soil reaction or pH greatly affects the behavior and availability of soil plant nutrient elements as well as those of toxic substances in the soil constitutes a very important limiting factor for plant growth and development. Thus, in soils with a high degree of acidity or those with very low pH values, aluminum is rendered so soluble that its concentration in the soil solution becomes toxic to the growing plants. On the other hand, in soils of very high alkalinity or those with very high pH values, iron, manganese, copper and zinc are rendered unavailable to plants which in turn exhibit malnutrition or abnormal growth. Shown in *Figure 25* is the Truog Chart showing the general trend of the relation of soil reaction to the availability of plant nutrient elements.

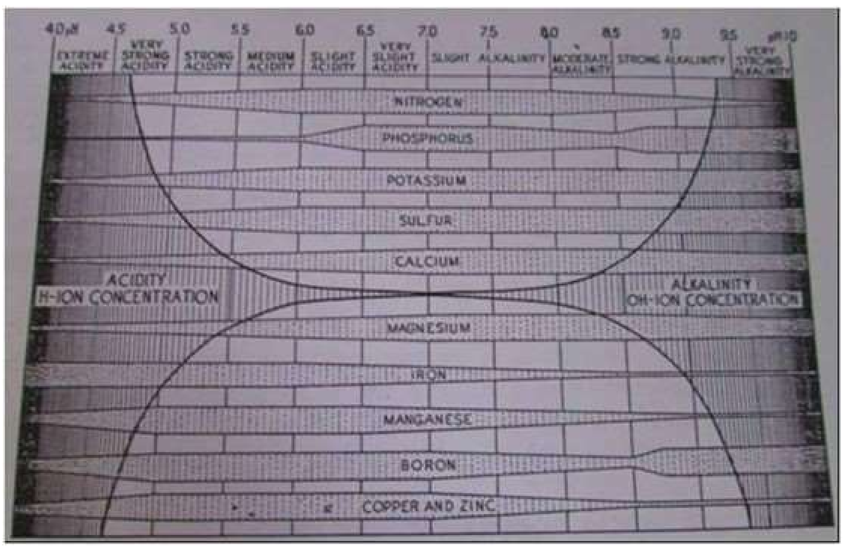


Figure 25 - Chart Showing General Trend of Relation of Reaction to Availability of Plant Nutrients (Adopted from Truog, 1951).

Shown in *Figure 26* is the soil pH of the 6 soil sapling locations within the three (3) parcels of the project area. The laboratory analysis using the EPA 9045d/electrometric method revealed that the pH of the soil in four of the sampling locations as rated by the Bureau of Soils and Water Management (BSWM)to be slightly acid (i.e. pH of 6.1 to 6.6) given by sampling locations 1, 4, 5 and 6 of pH 6.4, 6.4, 6.4 and 6.3, respectively. The lowest pH level which is considered to be moderately acid was found in soil sampling location 2 of 5.8 pH. The highest was given by soil sampling location 3 of 7.8 pH which is rated as slightly alkaline. The observed slight differences in terms of soil pH may be due to the present land use. Soil Sampling location 3 of Parel 2 is vegetated with shrub species of Bamboo and on the elevated portions of the sampling site are the presence of limestone hills. In contrast, soil sampling location 2 present land use is grassland with undulating terrain. Grassland are known to have acidic soil reactions.

Further, availability of plant nutrients is highly governed by pH. These values clearly indicate that the availability of almost all of the macro essential nutrients needed by plants for their growth and reproduction is at its optimum (i.e. pH 5.6 – 7.8). Beyond this soil pH range especially the essential micro-metallic elements are rendered to be unavailable. Besides, different plants have been found to have different pH preferences and tolerance limits. Some plants like rice, pineapple, and tobacco at pH 5.5 to 6.1 they grow favorably, while other crops like sugarcane and oranges prefer less acid or even slightly alkaline soil conditions (pH 6.2 – 7.8).

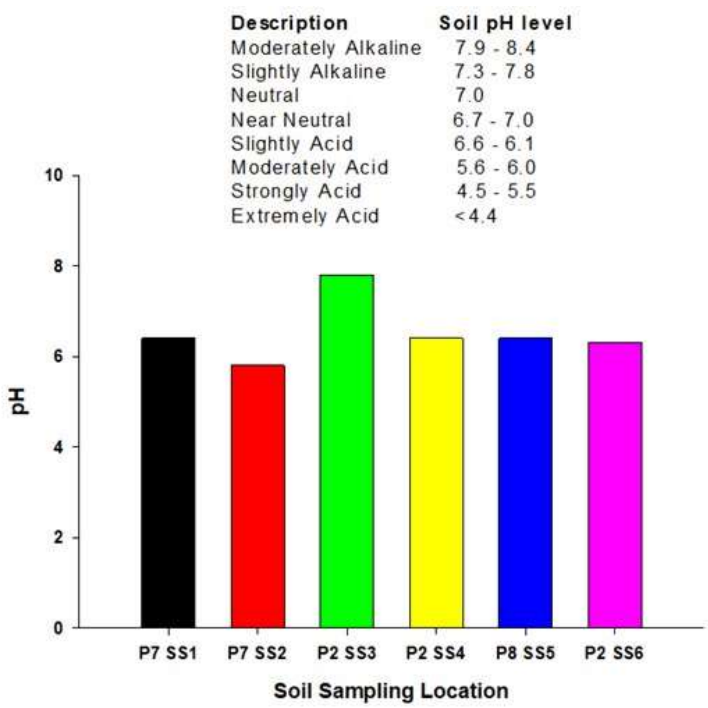


Figure 26 - Soil pH of the Soil Sampling Locations

2.1.4.1.2 Soil Organic Matter Content (SOM)

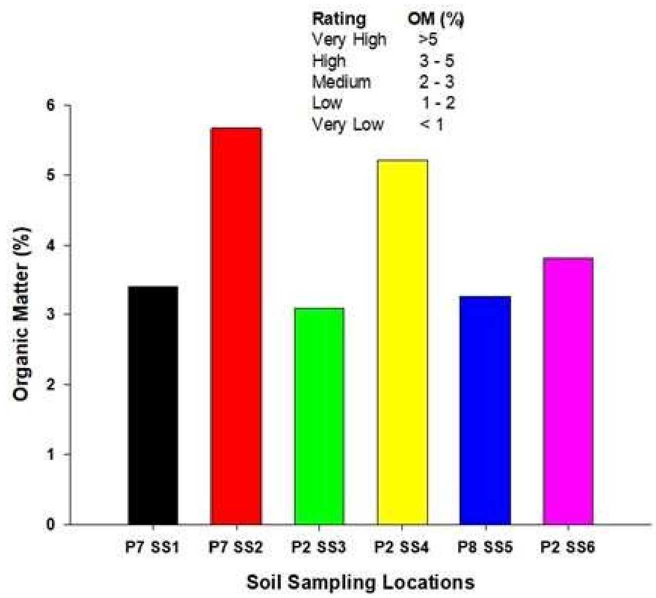


Figure 27 - Soil Organic Matter Content of the Soil Sampling Locations.

Soil organic matter (SOM) serves multiple functions in the soil, including nutrient retention, water holding capacity, and soil aggregation and is a key indicator of soil quality. Soil organic matter levels have declined over the last century in the Philippine soils as a result of over-grazing the grasslands and, the conversion of grasslands to cultivated farmlands. This reduction has decreased soil fertility, increased the fertilization needs, and increased soil erosion in most areas of the Philippine archipelago.

The presence of high organic matter in the soil demonstrates the abundance of minerals and essential elements needed by plants. It also indicates good physical properties like high water retention capacity, increased gas exchange, easy workability and presence of considerable number of beneficial microorganisms that aids in the mineralization of the soil. In terms of soil fertility high OM content is highly desirable.

Shown in *Figure 27* the result of Titrimetric method of laboratory analysis of the SOM content of the surface soil (0 - 35 cm depth) sampling locations of the project site. When compared to the BSWM SOM set of standards, the soil sampling locations revealed to have a medium to very high SOM (i.e., 3 - >5% SOM content). The result indicated that the three (3) parcels of the mining site because of its undisturbed state have slowly accumulated organic matter in the soil surface. This desired soil quality will contribute to less soil erosion because one advantage of having a high SOM is the soil will resist soil erosion due to the high binding components given by the SOM material on its surface. It is, therefore, highly recommended to preserve and utilize the surface soil during the stripping operations of the project area by stockpiling and, utilized during progressive rehabilitation.

2.1.4.1.3 Soil Total Nitrogen Content

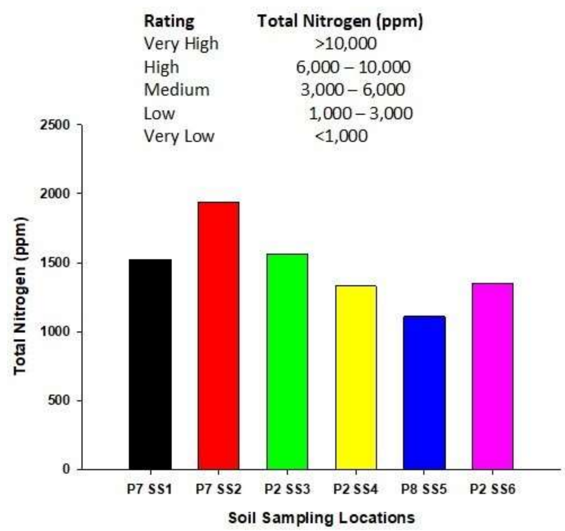


Figure 28 - Total Nitrogen Content of the Sampling Locations

Shown in *Figure 28* is the calculated laboratory analysis result of the total nitrogen (N) content in ppm of the soil sampling locations of the project site. All of the sampling sites indicated low nitrogen content in its surface that ranges from 1,110.0 – 1,940.0 ppm. An adequacy level standard value by the BSWM is 3,000 – 6,000 ppm of soil total N.

This observed low N values in the surface soil can be attributed to the inherent soil characteristics (Ultramafic) where it is highly leached soil. Among the essential plant nutrients in the soil Nitrogen is the most dynamic. It is easily lost through volatilization and leaching. The present land use of the area and the slope may be a contributing factor where, there is a very low vegetation cover, if present the vegetation exhibit stunted growth and yellowing of the leaves. This is a typical N deficiency symptom among plants.

2.1.4.1.4 Available Phosphorus of the Soil Sampling Locations

The exchangeable total Phosphorus (P) content of the soil sampling locations of within the project site is presented in *Figure 29*. All of the sites sampled showed very high levels of exchangeable total P (i.e. > 50 ppm). Lowest P value of 355.0 ppm was given by soil sampling location 3 in Parcel

2, while the highest of 633.0 ppm total P was given by soil sampling location 2 also in Parcel 2. It is noteworthy that Parcel 2 is having a very high P content.

Among the major essential plant nutrient elements P is the most often unavailable in Philippine soils. Unavailability or P fixation in the soil is often due to very low or very high pH. Stunted growth is the most characteristic symptom. This is very evident in the site where if, there are any vegetation exhibit a very stunted growth, exhibit reddish to purplish coloration of the leaves.

Essential element P is normally abundant among Philippine soils but its availability to plants is highly governed by the pH of the soil. At a soil pH above 5.5 most of the phosphates react with calcium to form calcium phosphates. The highest solubility for calcium phosphates is around pH 7.2. The highest level of plant available phosphorus parallels this solubility range. In this case, the deposition of Calcium coming from the weathering of the limestone hills present in the mining site promote the solubility of P on the soil in excessive levels and, may contribute to vegetation cover nutrient imbalance.

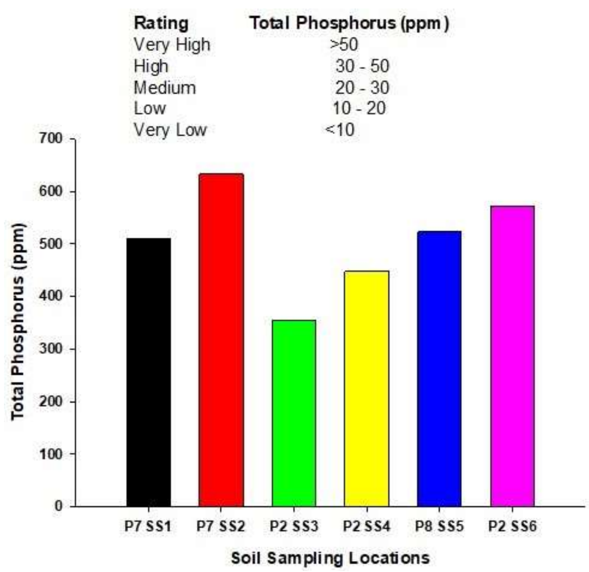


Figure 29 - Total Exchangeable Phosphorus Content of the Sampling Locations

2.1.4.1.5 Soil Exchangeable Potassium of the Sampling Locations

Potassium (K) is one of the essential macro elements that is responsible for the improved quality of the marketable part of the plant like fruits in terms of color, texture and, eating quality. A soil with high pH increases the availability of K in soil solution. In relation to plant nutrition, plants absorb K in luxurious quantities. However, K is easily lost in the soil. Being highly soluble with water it is easily lost through leaching and runoff.

Using the BSWM set of standards for exchangeable K, the flame atomic absorption spectrophotometry (FAAS) laboratory test (*Figure 30*) shows that the soil of the project site (i.e. SS1, SS2, SS3, SS4, SS5, and SS6) contain low exchangeable K of 65.0, 117.0, 109.0, 47.0, 52.0 and, 51.0 respectively.

These results are typical chemical properties of ultramafic soils where, most of the basic cations are either leached or lost thru surface runoff.

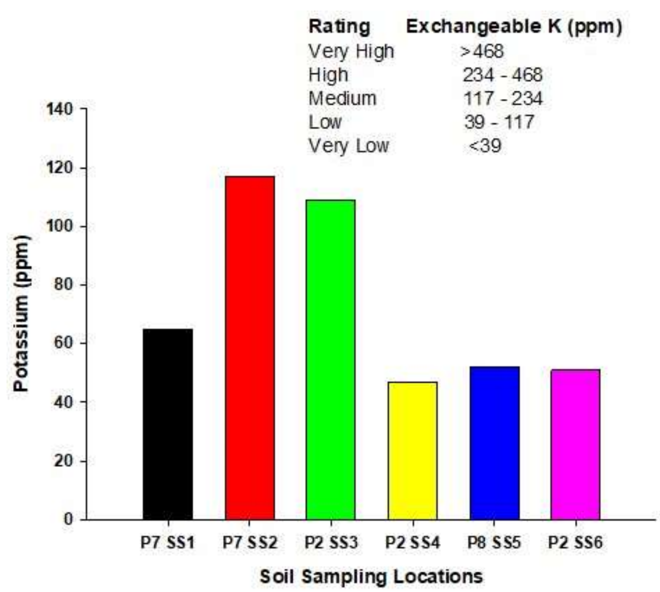


Figure 30 - Exchangeable Potassium of the Soil Sampling Locations

2.1.4.1.6 Soil Exchangeable Calcium of the Sampling Locations

FAAS Laboratory test of the six soil sampling sites (*Figure 31*) revealed that all of the soil have a very low detectable calcium (Ca) in SS1, SS2, SS3, SS4, SS5 and SS6 of 24.0, 30.0, 28.0, 25.0, 24.0 and, 18.0 ppm Ca, respectively.

The occurrence of low Ca content can be observed in serpentine soils (High Magnesium content derived from ultramafic rocks) with high soil pH values. This is probably because, the soil parent material where these soils are developed originated from poor-grade limestone rocks mixed with highly weathered basalts and chalk-white tuffaceous rocks.

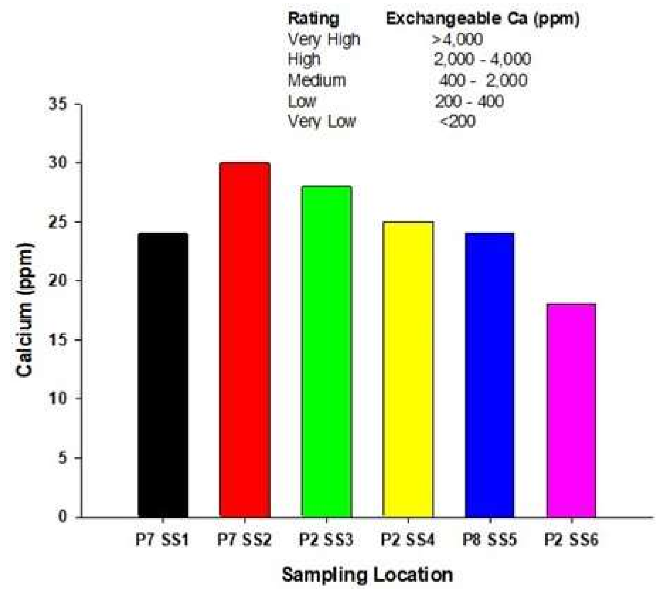


Figure 31 - Exchangeable Calcium of the Soil Sampling Locations

2.1.4.1.7 Exchangeable Magnesium of the Soil Sampling Locations

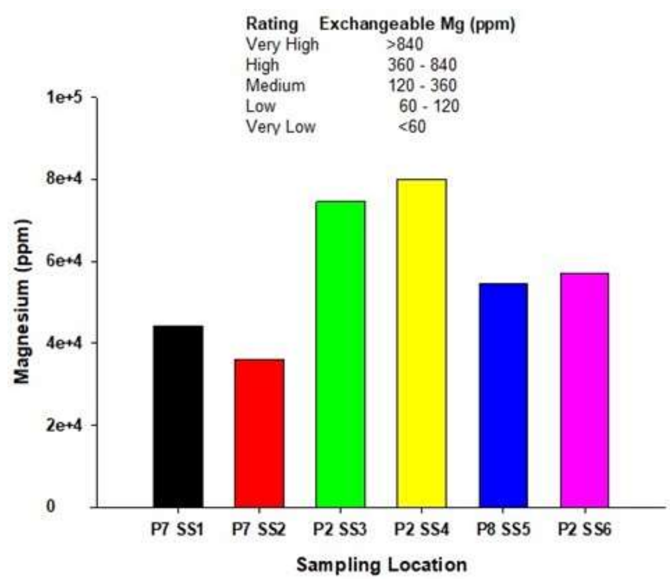


Figure 32. - Exchangeable Magnesium of the Soil Sampling Locations

Magnesium (Mg) as an essential nutrients in higher plants is a component of the green pigment in the plant leaves (i.e. chlorophyll) and, act as catalyst to the translocation of phosphorus in the plant vascular tissues. It also aids in the formation of fats and oil in fruits.

As Shown in *Figure 32*, the levels of exchangeable Mg ranges from 36,200.0 - 80,100.0 ppm (i.e. given by soil sampling site 2 and soil sampling site 4 respectively).

The FAAS laboratory results showed a very high amount of Mg is present in all of the six soil sampling sites (*Figure 32*). This is a typical characteristics of soil derived from ultramafic rocks (i.e. called serpentine soils). Considering the high pH level of the soil sampling locations, elevated Mg content is slightly exhibiting toxicity problems of the existing vegetation. At high pH (above 7.5 pH) the solubility of many nutrients is reduced. As a result, these nutrients are precipitated as solid materials that plants cannot use. In most cases the solution of these basic cations is too low to sustain healthy plant growth.

2.1.4.1.8 <u>Exchangeable Sodium Content of the Soil Locations</u>

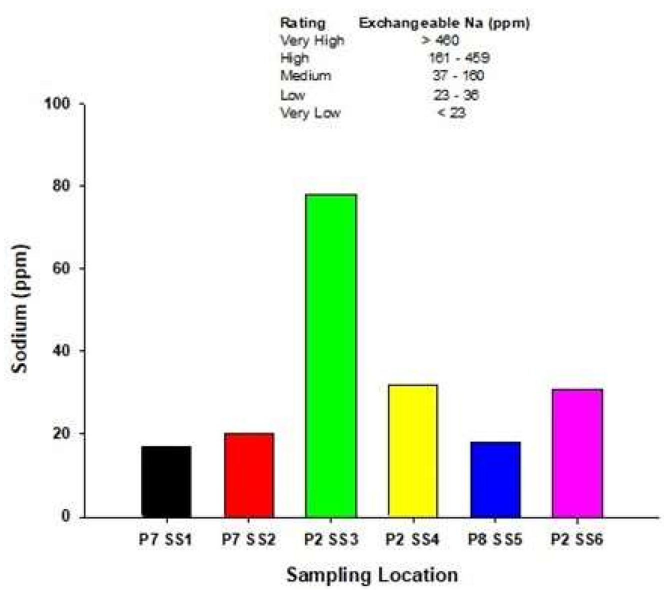


Figure 33 - Exchangeable Sodium of the Soil Sampling Locations

Soil provides sodium (Na) in plants. There is a natural accumulation of sodium in soil from fertilizers, pesticides, herbicides, run off from shallow salt-laden waters and the breakdown of minerals which release salt. The exchangeable Na is very necessary for the plant in order to maintain turgidity of the cell wall. Excess Na in soil gets taken up by plant roots can cause serious vitality problems. Plants exposed to excessive Na will wilt as a result of plasmolysis.

Sodium (Na) is found in many minerals and is released when they break down over time. The majority of sodium pockets in soil are from concentrated runoff of pesticides, Weedicides, fertilizers and other soil amendments.

Figure 33 shows the Na content of the project soil sampling sites. Three (3) of the sampling sites have very low Na content of 17.0, 20.0 and, 18.0 ppm for SS1 SS2 and, SS5, respectively. Low Na content was found in SS6 of 31.0ppm. Highest Na content was found in SS3 of 78.0 ppm, and is considered to be medium Na content when compared to the BSWM set of standards for Na. These results clearly indicate that there is no apparent salinity problem in the project area.

3.1.9 Heavy Metal Analysis of the Soil Sampling Locations

Mining, manufacturing, and the use of synthetic products (e.g. pesticides, paints, batteries, industrial waste, and land application of industrial or domestic sludge) can result in heavy metal contamination of urban and agricultural soils (Soil Quality - Urban Technical Note 2000). Heavy metals also occur naturally, but rarely at toxic levels. Potentially contaminated soils may occur at old landfill sites (particularly those that accepted industrial wastes), old orchards that used insecticides containing arsenic as an active ingredient, fields that had past applications of waste water or municipal sludge, areas in or around mining waste piles and tailings, industrial areas where chemicals may have been dumped on the ground, or in areas downwind from industrial sites. Excess heavy metal accumulation in soils is toxic to humans and other animals. Exposure to heavy metals is normally chronic (exposure over a longer period of time), due to food chain transfer. Acute (immediate) poisoning from heavy metals is rare through ingestion or dermal contact but, is possible. Chronic problems associated with long-term heavy metal exposures to man to cite examples are:

- Lead – mental lapse.
- Cadmium – affects kidney, liver, and GI tract.
- Arsenic – skin poisoning, affects kidneys and central nervous system.

The most common problem causing *cationic* metals (metallic elements whose forms in soil are positively charged cations e.g., Pb^{2+}) are mercury, cadmium, lead, nickel, copper, zinc, chromium, and manganese. The most common anionic compounds (elements whose forms in soil are combined with oxygen and are negatively charged e.g., MoO_4^{2-}) are arsenic, molybdenum, selenium, and boron.

Results of the Heavy metal analysis were compared to the United States Environmental Protection Agency (US EPA, 1993) standards for Lead and Mercury.

Laboratory FAAS analysis of The Heavy metal Lead (Pb) in the six soil sampling locations was not detected. Indicating the absence of heavy metal mercury in the project site.

The Heavy metal Mercury (Hg) in the six soil sampling locations as shown in *Figure 34*, showed that all of the soil sampling locations have elevated levels of Hg when compared to the US EPA standard of 0.3 ppm. The highest Hg content was found in SS2 of 4.1 ppm and the lowest of 0.4 ppm was detected in SS6, respectively.

All of the sampling sites have more or less the same present land use of open grassland with patchy forest trees. Hg in soils has increased by a factor of 3 to 10 in recent times mainly due to combustion of fossil fuels combined with long-range atmospheric transport processes. Adsorption is the dominant process mercury's fate in the terrestrial environment (Hogg et al., 1978). In neutral and low organic matter soils, like the project area depends on iron and clay minerals as important adsorption sites of Hg (OECD 1993).

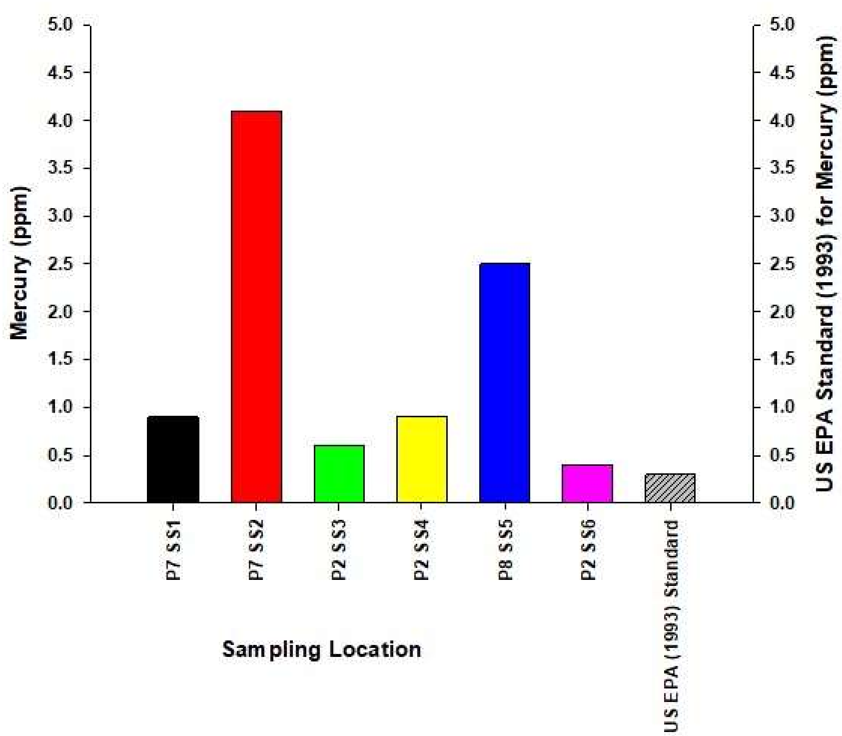


Figure 34 - Heavy Metal Mercury Content of the Soil Sampling Locations

In all the above observations, the ultimate impacts of metals and heavy metal toxicity results to reduction in the capacity to produce food by photosynthesis by plants. Thus, in soils laden with heavy metals, plant productivity suffers so that biomass production becomes low. This is the reason perhaps why in mining areas, plant growth is reduced, some plants do not thrive and only a limited number of species (only the tolerant ones) survive (Regis, 2006).

2.1.4.2 Soil Physical Properties of Sampling Locations in Relation to Soil Erosion/Siltation

2.1.4.2.1 <u>Slake Test</u>

Slaking is the breakdown of large, air-dry soil aggregates (>2-5 mm) into smaller sized micro-aggregates (<0.25 mm) when they are suddenly immersed in water. Slaking occurs when aggregates are not strong enough to withstand internal stresses caused by rapid water uptake. Internal stresses result from differential swelling of clay particles, trapped and escaping air in soil pores, rapid release of heat during wetting, and the mechanical action of moving water.

In contrast to slaking, tests for aggregate stability measures how well the soil withstands external destructive forces, such as the splashing impact of raindrops. Poor aggregate stability and slaking resulted to the dispersion of soil particles that settle and blocks the soil micro-pores, and cause surface sealing, reduced infiltration and plant available water, and results to increased runoff and erosion.

Why it is important: Slaking indicates the stability of soil aggregates resistance to erosion and suggests how well soil can maintain its structure to provide water and air for plants and soil biota when it is rapidly wetted. Limited slaking suggests that organic matter is present in soil to help bind soil particles and micro-aggregates into larger, stable aggregates.

All of the six soil sampling locations were field tested for their soil aggregate slaking property and, for brevity slaking test for P7 SS1 is illustrated in *Figure 35* for the start of the slake test and at the end of the test (*Figure 36*) after approx. 10 minutes.

Figure 35 - Start of Slake Test, P7 SS1

Figure 36 - End of Slake Test, P7 SS1

Soil response to rapid wetting is observed for a period of 10 minutes. The result shows that the soil can be classified as Class 4 or very stable (*Figure 36*). There is no slumping of particles after 10 minutes of submergence in water. The whole fragment remains intact with no evidence of swelling or disintegration of particles.

Parcel 7 SS2 surface soil wet cohesiveness was tested in situ during the field soil sampling activities. A representative fragment of the soil surface was collected and immersed in distilled water inside a stainless steel basin (*Figure 37*). Slumping occurred within 5 seconds, where there is observed rapid air bubble evolution. A period of 10 minutes of water submergence is allowed before observance of any slaking property. *Figure 38* showed after 10 minutes of water immersion, there was a total slumping of particles of the whole fragment. The surface soil found in Parcel 7 SS2 is therefore classified as Class 1 very unstable.

Figure 37 - Start of Slake Test, P7 SS2

Figure 38 - End of Slake Test, P7 SS2

Figure 39 - Start of Slake Test P2 SS3

Figure 40 - End of Slake Test P2 SS3

The Slake test procedure is repeated in the Top end portion of Parcel 2. (*Figure 39*). A period of 10 minutes of water submergence is allowed before observance of any slaking property of the soil. *Figure 40* shows that the soil of Parcel 2 on the Top end portion is very stable (Class 4). There was no slumping of sub-crust.

Figure 41 - Start of Slake Test of P2 SS4

Figure 42 - End of Slake Test of P2 SS4

Reaching the middle portion of Parcel 2 a separate slake test were made and is presented *Figure 41* and *Figure 42*. After 10 minutes of water submergence a slight slumping of the crust was observed. This portion of Parcel 2 can be classified as Class 3 or moderately Stable.

Figure 43 - Start of Slake Test P8 SS5

Figure 44 - End of Slake Test P8 SS5

Slake test for Parcel 8 SS5 is presented in *Figure 43* and *Figure 44*. There was an immediate slight slumping of the sub crust observed of the soil fragment within 5 -10 seconds after water submergence (*Figure 43*). After 10 minutes there was no further crust collapse observed. The soil of Parcel 8 can be classified as Class 3 or moderately stable. Slumping of sub-crust but most of the crust is intact.

Shown in *Figure 45* and *Figure 46* is the slake test conducted in the end portion of Parcel 2. Upon water immersion of the soil fragment a slight slumping was observed, numerous air bubbles emerged (*Figure 45*). After 10 minutes, there was no further slumping observed the sub crust remains intact. In this case, the end portion of Parel 2 can be classified as Class 3

Figure 45 - Start of Slake Test P2 SS6

Figure 46 - End of Slake Test P2 SS6

Table 25 - Slaking Test Results of the six Soil Sampling Location

Soil Sampling Location	Date measured	Start of measurement	End of Measurement	Slake Test Result
P7 SS1	May 12, 2018	9:00 am	9:10 am	Class 4
P7 SS2	May 12, 2018	9:36 am	9:45 am	Class 1
P2 SS3	May 12, 2018	10:53 am	11:04	Class 4
P2 SS4	May 12, 2018	11:17 am	11:27 am	Class 3
P8 SS5	May 12, 2018	2.31 pm	2.42pm	Class 3
P2 SS6	May 12, 2018	4:53pm	5:03 pm	Class 3

The soil behavior of the six soil sampling sites within parcels 7,2 and 8 when subjected to rapid wetting (Slaking test or soil coherence that described how does the soil matrix behave under rapid wetting to resist erosion) is presented in *Table 25*. Over all, the soils of the project area when subjected to rapid wetting can be classified as moderately stable. However, the ultramafic soils when subjected to mechanical manipulation (i.e. stripping and excavations) it becomes very unstable and prone to erosion and, greatly contribute to the siltation of natural water ways therefore, there is a great need of soil conservation measures to mitigate soil erosion/siltation problems. Perhaps this is the case in P7 SS2 where there might be a previous soil disturbance (i.e. excavations during exploration stage) rendering the soil to become very unstable when subjected to rapid wetting.

2.1.4.3 Soil Erosion

Soil Erosion is the process of soil detachment and movement of soil from the land surface by running water, wind or by gravity. The surface soil which are easily detached by raindrops are carried by run off and, are easily shifted through small channel where sediments accumulates and pushed together closely forming alluvial fans. This natural process being repeated during heavy rainfall events accelerates soil erosion. There are two kinds of erosion; namely, normal or geologic and accelerated erosion.

Normal or Geologic erosion – Normal or geologic erosion takes place in a natural or undisturbed condition under the canopy of forest, grass, ground litter, and in underground network of binding roots. Geologic erosion is a slow process; the removal of the soil by either water or wind is balanced by the formation of the soil from the parent material underneath. This kind of erosion is beneficial in the sense that there is a constant renewal of the fertility of the soil.

Accelerated erosion - Accelerated erosion is the process brought about by man's activities on the land, thereby disturbing the equilibrium between soil building and soil removal. This kind of erosion is destructive as it removes soil particles very much faster than the formation of soils from materials underneath. The loss of the surface soil which contains most of the fertility means also the decline in terms of productivity output of the soil (i.e. biomass production decline). Soil erosion in the Philippines is caused mainly by water. The different kinds of accelerated erosion are: gully, rill, streambank and sheet erosion.

The province of Zambales was observed by the BSWM (1988) to be greatly affected by soil erosion. Most of the areas are susceptible to erosion because of its hilly to mountainous topography. It is therefore greatly relevant to look very closely into this problem in order to determine appropriate control technology considering the proposed project is the mineral extraction of nickel that greatly involve soil extraction and movement.

In Zambales Province the different kinds of erosion observed are:

a. **Gully erosion-** It occurs on paths of concentrated flow down a slope and is the cutting of deep narrow strips or gullies on the face thereof. Gullies occur both on alluvial plains as well as on uplands. On a plain where drainage outlets are not protected, the edges of the plain are gradually eroded which consequently form into deep vertical cuts. These gullies, if not checked gradually destroy the plain. On uplands, gullying occurs mostly on slopes where runoff continually drains. This happens when farmers cultivates their fields up and down the slopes. Some gullies are small, but others are big that machineries and human cannot cross. Gullies grow bigger each year.

b. **Rill Erosion**- This kind of erosion is the washing off of the soil by the formation of tiny incisions of a few centimeters depth and width which run down the slopes of an unprotected cultivated land. This is attributed to the method of planning and arranging the furrows along the slope of the land. Such rills maybe erased by ordinary plowing. This type of erosion marks the beginning of the formation of more serious kinds of erosion.

c. **Streambank erosion** – This king of erosion occurs along the sides or banks of rivers during flood events and the water have increased velocity and volume. The removal of soil particles is through scouring and undercutting below the water surface. It is very destructive particularly on such lands where the substrata are coarse or medium textured soils. The flowing water undermines the lower part of the river or stream bank particularly along its outer curve thus causing the upper part to fall by its own weight.

2.1.4.3.1 *Factors Affecting Soil Erosion*

Soil erosion occurs when water runs over the surface of a sloping land. This water running over the surface is called runoff. The rate of soil erosion will depend upon the speed of surface runoff. The volume of runoff as well as its speed depends upon the soil slope, vegetation and intensity of rainfall in the area.

a. Intensity of Rainfall

Rainfall intensity is a factor in erosion. A region with rainfall distributed throughout the year will have less soil erosion than other area where the same amount of rainfall occurs but only within a period of six months. In the latter area the intensity of rainfall is much bigger and hence the amount of runoff is correspondingly greater. Short duration but heavy rainfall is far more damaging than the gentle rain carrying a long period. This is because intense rainfalls over short period produce more runoff due to the unbalanced rate between the volumes of water that is being absorbed by the soil. In the former case, the intensity of rainfall is less giving more time for the water to infiltrate into the soil, hence less runoff.

b. Soil Characteristics

There are several characteristics of soil, such as physical, biological and chemical. The soil possesses certain physical characteristics which influence its erodibility. Under similar conditions of climate, relief and vegetative cover, there are marked differences in the erodibility of different soils. In some cases sandy loam textured soils are more susceptible to erosion than clay loam soils. The physical characteristics have the greatest influence to resist erosion it includes the soil texture, bulk density (i.e. degree of compaction), soil structure (arrangement of the soil particles in the soil matrix), porosity and permeability are important factors in the formation of runoff. The greater is the aggregation of the soil and absorbing quality of the soil or infiltration of water into the soil the lower is runoff will be formed. Different soil types differ in porosity and permeability. Also soils rich in organic matter are porous and will absorb more water readily than those poor in it. When soil organic matter content is high in a certain area, the water holding capacity is high, thus, erosion process is reduced. There is also more macro and micro pore spaces in between particles that allow high level of water infiltration during rainfall event.

c. Slope Gradient and Length

The degree and length of the slope influences erosion. A terrain with slopes over 8 percent accounts for much of the erosion problem in the province. *Table 26* and *Table 27* show the different slope classes in Zambales Province and slope classes per landscape with their corresponding area, respectively.

Table 26 - Slope Classes in the Province of Zambales

Slope Class	Percent Slope	Area (Has.)	Percent (%) Land Area
M	0 - 3	54, 168	14.6
N	3- 8	21, 924	5.9
O	8 - 18	50, 701	13.7
P	18 - 30	71, 568	19.3
Q	30 - 50	98,858	26.6
Total Land Area		371,169	

Source: BSWM (1988).

Table 27 - Slope Classes per Landscape

Landscape	Slope percentage	Area (has)	Percent of the Total Land Area of Zambales
Lowland	0 - 8	66,560	17.93
Upland	0 - 3	4,035	1.08
	3 - 8	5,489	1.5
	8 - 18	4,200	1.11
Hilly	8 - 18	23,124	6.23
	18 - 30	18,612	5.0
	30 - 60	10,596	2.85
Mountainous	8 - 18	23,377	6.3
	18 - 30	52,956	14.3
	30 - 50	88,262	23.8

Landscape	Slope percentage	Area (has)	Percent of the Total Land Area of Zambales
	> 50	73,950	19.9
Total		**371,169.00**	**100.00**

Source: BSWM (1988).

2.1.4.3.2 Present Status of Erosion in the Province of Zambales

The erosion status of Zambales has been determined and evaluated by the BSWM thru actual field observations. The degree of erosion has been categorized based from the slope, present land use and vegetation and, the different factors affecting soil erosion. The different erosion classes as determined by the BSWM are:

a. E_o – No apparent erosion

These areas are the coastal and broad alluvial plains with slope ranging 0 - 3% have no apparent erosion. A total of 73,360 has or 19.76% of Zambales has no apparent erosion.

b. E1 – Slight erosion

Sloping to undulating area with slopes ranging from 3 – 18% cultivated for upland crops are subject to slight erosion or a total of 188,165 has or 50.696% of the total land area of the province of Zambales.

c. E2 Moderate erosion

Areas under open grassland and secondary growth forest are found to be moderately to severely eroded. An area of 100,240 or 27.004% of the total area of Zambales has been identified.

d. E_W – Riverwash

This covers 2.54% or 9,404 has of the total land area of Zambales. Riverwash is the unpronounced dissection of streamflow resulting to deposition/sedimentation and sometimes erosion. These are occupied by river streams and lakes.

2.1.4.3.3 Methods of Erosion Control

There are two general ways of soil erosion; namely (1) Vegetative measures and, (2) Mechanical Means.

Vegetative measures are simpler and easier to apply, while mechanical means usually require engineering aids tools and, machineries. The former is usually employed on land that is nearly level to gently rolling, while the latter is adopted to rolling and undulating land. Some times both means are employed simultaneously, or one in support of the other. This is highly applicable in the proposed Zambales Ferro-Nickel Plant and Mining Expansion Project where the project is a large scale surface soil mining and extraction process.

2.1.4.3.3.1 Vegetative Measures

Control of erosion by vegetative means deals with the use of plants following the normal farming operations and the use of ordinary implements and machinery.

Cover Cropping- Use of vegetative cover is the most appropriate erosion control in this type of mining activities (I.e. surface stripping mining method). It is the first protection against runoff and erosion. When planting cover crops mulches of dead stems, twigs, leaves, or straw are necessary since cover crops offer protection only after they have attained considerable growth.

Grassed Waterways- Waterways in soils work are either natural or man-made depressions on sloping areas which serve as passageways for water that goer through an idle space from adjacent land or accumulating on it due to rain. They are important in any scheme of soil and water conservation. Naturally located depressions serve the purpose best. Man made canals strategically laid are also necessary for more efficient discharge of runoff. The establishment of dense vegetative cover over all waterways is imperative. Grasses readily adaptable to the area should be used, but whenever practicable those species which form a dense turf are preferable. In as much as waterways are supposed to carry heavy flows during certain periods they should be designed to handle maximum runoff from the heaviest rainfall occurring in the locality once in about 50 years or to the maximum of once every 100 years. Grassed waterways are essential whenever excess runoff accumulate.

2.1.4.3.4 Mechanical Measures

This is the most common practice in mining that involve the surface stripping and extraction of the desired raw material. On steep slopes vegetative measures offer inadequate protection for the soil.

Terracing- Terraces are mechanical measures of soil conservation and are differentiated into three types; namely (1) absorptive, (2) bench, and (3) drainage. In almost all of the types of mining methods the bench type is the only one that is utilized.

Absorptive terrace or ridge type is designed for moisture conservation. This is essential in the project since water is a common problem in ultramafic soils. It is adapted to gentler slopes and adsorptive soils (e.g. ultramafic and lateritic soils under its undisturbed conditions are well drained).

Bench terrace is constructed on the contour. Mainly it is constructed on a mining site to ease the extraction of the raw ore. It is highly adapted to steep slopes.

Drainage terrace or broad channel type is designed to conduct water from a field with low velocity

Diversion Ditches- Diversion ditches or diversion terraces are built to intercept the runoff from drainage areas. They are usually larger that field terraces. They are designed to protect vegetated areas from hillside runoff by providing for a passage way from the fields to other nearby areas where it is spread or dispersed. Where adjacent slopes generate runoff towards a terraced area, diversion ditches carry the water away from the terrace system, or if towards a gully diverting the water assists in controlling further enlargement.

This structure can also greatly reduce the amount of runoff that will enter the siltation/sedimentation ponds constructed to intercept runoff and at the same time provide silt and clay particles to settle before any discharges are made. Diversion ditches conveys silt laden runoff to nearby fields and provide adsorption of the water giving more time to percolate and contain the red colored silt in entering natural water ways or ultimately the ocean.

An efficient system of soil management under a mine site needs much support of the vegetative and a mechanical measure discussed is indeed, necessary to combat soil erosion and siltation. The different practices to be followed or adopted should form a mine environmental program that as a unit could fit the kind of soil or kinds of soils within the mine so that the end attained is the combine beneficial effects of the many interacting processes involved. The mining environment people of the company should first appraise the erosion hazards in the mine, then plan a vegetation system and supporting conservation practices to reduce or offset the erosion hazards.

2.1.5 Terrestrial Flora and Fauna

2.1.5.1 Flora

2.1.5.1.1 Methodology

Establishment of the plots necessary for the assessment were done using available online satellite images. Tracking and plotting were done using OruxMaps.

To assess the floral assemblage of the area, nested-quadrat technique was done. A transect of approximately two (2) kilometers were established in 6 stations/transects. These stations were selected to represent different forest covers identified inside the study area. Along the transect, three (3) 20x20 m plots were established to identify the canopy, intermediate and understory floral cover of the area.

For the canopy layer, only trees with diameter-at-breast-height (DBH) > 10cm were included. For understorey, trees with 10cm>DBH>5cm were included, while those with DBH<5cm were counted on the understory and regenerants.

All other plant species that can be observed inside the area, but not covered by the plots, were also listed but were not included in the computation for the Importance Values. Refer to *Figure 47* **f**or the map of the assessment stations.

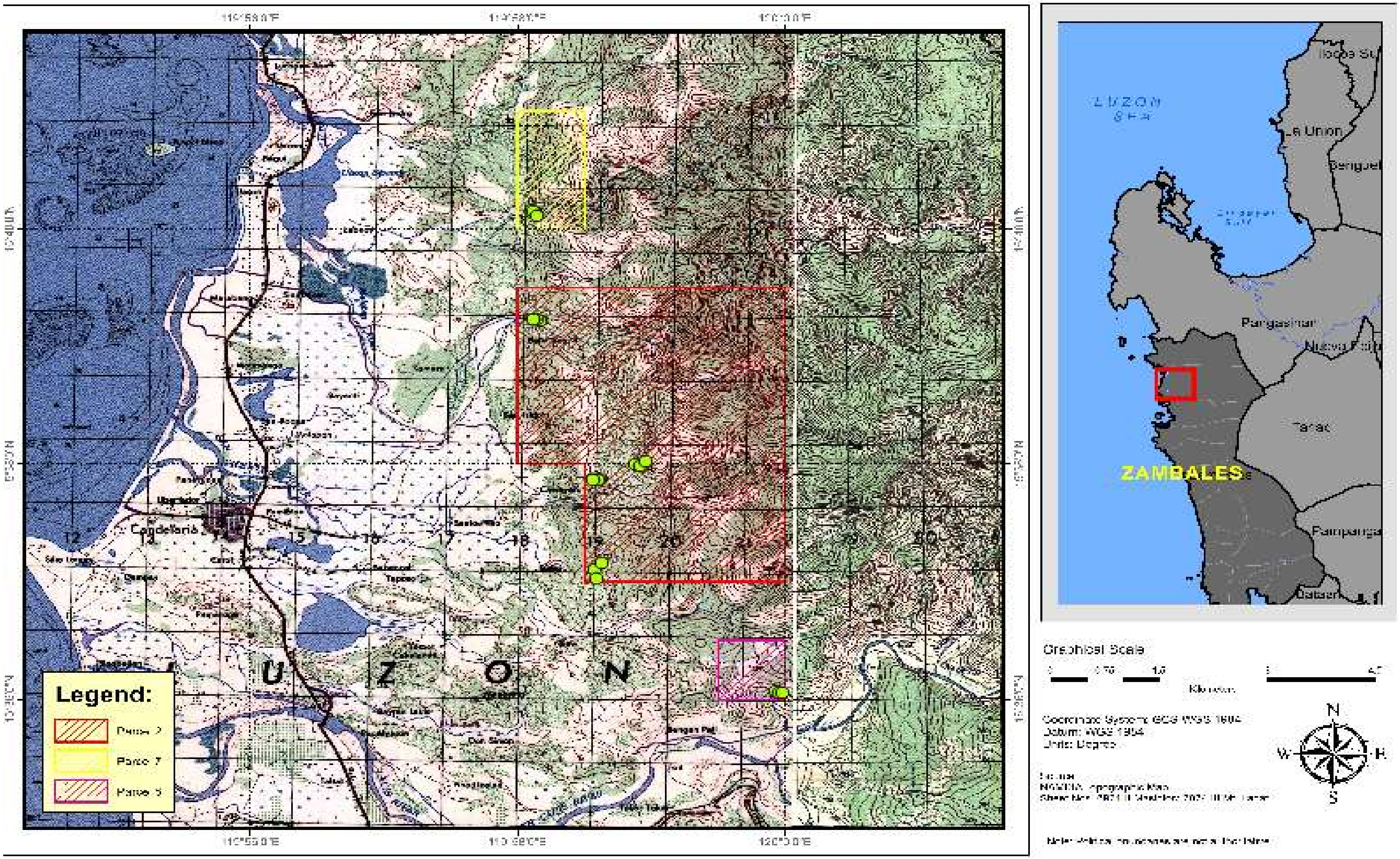


Figure 47 - Location of sampling sites for floral assessment.

For all of the floral species intercepted by the plots, parameters such as Density, Frequency and Dominance were computed. Relative values of these trees were used to calculate the Importance Values (IVs) of each trees assessed among all stations. Importance Values determine which species affects the area in terms of forest dynamics. The parameters computed were as follows:
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:

$$Density = \frac{Number\ of\ individual\ in\ a\ specific\ quadrat}{Size\ of\ the\ quadrat}$$

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:

$$Density = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ number\ of\ the\ individuals}$$

Frequency refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence.

$$AAbsolute\ frequency = \frac{Number\ of\ quadrats\ in\ which\ a\ species\ occured}{Number\ of\ quadrats\ studied}$$

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:

$$Relative\ frequency = \frac{Calculated\ absolute\ frequency\ of\ a\ species}{Total\ frequencies\ of\ all\ the\ species}\ x\ 100$$

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. These can be computed as:

$$Absolute\ dominance = Mean\ basal\ area\ (MBA)\ x\ No.of\ individuals\ of\ a\ species$$

$$Relative\ dominance = \frac{Dominance\ of\ a\ species}{Dominace\ of\ all\ species}\ x\ 100$$

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.

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

Where;

H' = Species diversity index
S = The number of species
Pi = The proportion of individuals of each species belonging to the i^{th} 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 28.*

Table 28 - The Fernando's Biodiversity Scale can be used to interpret the diversity indices

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

Relative Values	Shannon-Weiner Index (H')	Evenness
Low	2.00 – 2.49	0.15 – 0.24
Very Low	1.99 and below	0.14 and below

2.1.5.1.2 Results and Discussion

Assessment were conducted on random sites with different forest cover types. It was found that the area contains a variety of vege tation type ranging from closed forest, agroforestry area, and regeneration forests. The complete list of sampling stations is in *Table 29.*

Table 29 - Brief description of the assessed transects.

Station	Coordinates	Elevation (masl)	Dominant Type of Vegetation
1	50P 818698 1730021	71.73	Forest edge characterized by stands of trees with trees up to around 20m tall like Balete (*Ficus benjamina* L.) and Agoho (*Casuarina equisitifolia* L.)
2	50 P 817971 1734413	62.49	Agroforestry with patches of grassland area. Characterized by dominance of fruiting trees such as mango (*Mangifera indica* L.) and guyabano (*Annona muricata* L.)
3	51 P 178563 1726601	83.54	Mixed brushland with stunted growth forests characterized by dominance of small trees and shrubs up to 5m in height. Observed species includes *Parasponia rugosa* Blume and *Acacia mangium* Willd
4	50 P 818034 1732929	72.97	Closed, mixed forest with trees up to 30m in height. Observed species includes mahogany (*Swietenia macrophylla* Jacq) and binunga (*Macaranga tanarius* L. Muell.-Arg.)

Station	Coordinates	Elevation (masl)	Dominant Type of Vegetation
5	50 P 818121 1728664	42.82	Riverine area with small trees and shrubs. Dominant species includes kakauate (*Gliciredia sepium* Jacq.) and Kamuning (*Murraya paniculata* Jacq.)
6	50 P 819333 1730261	66.57	Regeneration forest characterized by small trees and shrubs. Observed dominant species includes *Leptospermum amboinense* Reinw ex. Blume and katmon (*Dillenia luzoniensis* Vidal. Merr.)

The first station is a forest edge located at 71.73 masl. It is characterized by trees with varying height from an estimated 20 meter-tall Balete (*Ficus benjamina* L.), to an average-height Agoho (*Casuarina aequisitifolia* L.) and smaller trees such as Apatot (*Morinda citrifolia* Lam). Stands of the endemic Katmon (*D. luzoniensis*) were also observed on the site.

The second station is an agroforestry area located at a forest edge characterized by large mango and banaba (*Lagerstroemia speciosa* Pers) trees. Anthropogenic-activities were observed nearby the station i.e. small-scale coal-making of presumably residents of neighboring communities. Stands of Binayuyo (*Antidesma ghaesembilla* Gaertn) and Bignay (*A. bunius* Spreng) were also found.

For the third station, an area dominated by small trees with heights <5m and shrubs were assessed. Small stands of Katmon (*D. luzoniensis* Vidal) and Kasoy (*Anacardum occidentale* L.) were the dominant species present in the site.

Station four is a closed forest where high stands (>10m) of Balete and Gmelina (*Gmelina arborea*) were observed. It is situated near a cavern which is visited by the locals for religious purposes. Multiple species of palms were also observed on the site. It is also notable that in this station, stands of Mahogany (**insert sci name)**, which is one of the known invasive tree species in the country thrives tall with ~20m height were observed.

Station five is a riverine area dominated by small trees and shrubs. Kakawate (*G. sepium)* dominated the area alongside other species such as Kamuning (*Murraya paniculata* L.) and lianas such as Hanopol (*Poikilospermum suaveolens* Blume Merr.).

Station six is a conglomerate of small trees. According to a resident the area is near a then-operating small scale mining facility and some of the observed trees today were regenerants. Also, a program of local government environment office aimed to reforest the area. This is supported by the presence of stands of some reforestation species such as Batino (*Alstonia macrophylla* Wall. ex G.Don) and Mangium, *(Acacia mangium)*.

Species composition and Diversity Indices

A total of 113 species belonging to 47 families were observed in the study area. All other plant species that can be observed inside the area but not covered by the plots were also included in the assessment for the general species composition but not in the specific computations for diversity indices and dominance in specific plots. *Table 30* shows the complete list of observed floral species in the area.

Table 30 - List of all floral species observed on the area.

Scientific name	Family	Common Name	Habit
Acacia mangium Willd.	Fabaceae	Mangium	tree
Acrostichum aureum L.	Pteridaceae	Palaypay	fern
Ageratum conyzoides L.	Asteraceae	Bulak-manok	shrubs
Adiantum philippense L.	Pteridaceae	Kaikai	fern
*Alstonia macrophylla*Wall. ex G.Don	Apocynaceae	Batino	tree
Alstonia scholaris (L.) R.Br.	Apocynaceae	Dita	tree
*Anacardium occidentale*L.	Anacardiaceae	Kasuy	tree
Antidesma bunius (L.) Spreng.	Phyllanthaceae	Bignai	tree
Antidesma ghaesembilla Gaertn.	Phyllanthaceae	Binayuyu	tree
Ardisia pyramidalis (Cav.) Pers	Primulaceae	Tagiman	tree
Artocarpus blancoi (Elmer) Merr.	Moraceae	Antipolo/Tipolo	tree
Artocarpus heterophyllus Lam.	Moraceae	Nangka	tree
Asystasia gangetica (L.) T.Anderson	Acanthacea	Coromandel	shrubs
Averrhoa bilimbi L.	Oxalidaceae	kamias	tree
Axonopus compressus (Sw.) P.Beauv.	Poaceae	carpet grass	grass
Azadirachta indica A. Juss.	Meliaceae	Neem Tree	tree
Bauhinia malabarica Roxb.	Fabaceae	Alibangbang	tree
Buchanania arborescens (Bl.) Bl.	Anacardiaceae	Balitantan	tree

Scientific name	Family	Common Name	Habit
Canthium horridum Blume	Rubiaceae	malakape	tree
Canavalia cathartica Thouars	Fabaceae	Palang-palang	vine
Carica papaya L.	Caricaceae	papaya	herb
Cassia fistula L.	Fabaceae	Golden shower	tree
Cassythia filiformis L.	Lauraceae	Malabuhok	vine
Caryota sp.	Arecaceae	Fishtail palm	shrubs
Casuarina equisetifolia L.	Casuarinaceae	Agoho	tree
Chromolaena odorata (L.) R.M.King & H.Rob.	Verbenaceae	hagonoy	shrubs
Chrysophyllum cainito L.	Sapotaceae	Caimito	tree
Citrofortunella microcarpa (Bunge) D.O. Wijnands	Rutaceae	Kalamansi	tree
Citrus maxima (Burm. fil.) Osbeck	Rutaceae	Lukban	tree
Clitoria pubescens (Benth.) E.H.L.Krause	Fabaceae	pukinggang-baging	vine
Coccinia grandis (L.) Voigt	Cucurbitaceae	Tamling	vine
Colocasia bicolor C.L.Long & L.M.Cao	Araceae	Variegated gabi	herb
Cordia dichotoma G. Forster	Boraginaceae	Anonang	tree
Cynodon dactylon (L.) Pers.	Poaceae	kawad-kawad	grass
Cynometra ramiflora L.	Fabaceae	Balitbitan	tree
Desmodium tortuosum (Sw.)DC.	Fabaceae		herb
Dillenia luzoniensis Vid.Martelli	Dileniaceae	Katmon	tree
Diospyros discolor Willd.	Ebenaceae	Mabolo	tree
Elephantopus tomentosus L.	Asteraceae	malatabako	shrubs
Eleusine indica(L.) Gaertn.	Poaceae	Parag-is	grass
Eucalyptus deglupta Bl.	Myrtaceae	Bagras	tree
Euphorbia hirta L.	Euphorbiaceae	Tawa-tawa	herb
Ficus benjamina L.	Moraceae	rubber	tree
Ficus nota Merr.	Moraceae	Tibig	tree
Ficus septica Burm. fil.	Moraceae	Hauili	tree
Ficus pseudopalma Blanco	Moraceae	Niyog-niyogan	tree
Ficus ulmifolia Lam.	Moraceae	Isis	tree
Flacourtia jangomas (Lour.) Raeusch.	Flacourtiaceae	Governors plum	tree
Gliricidia sepium Jacq. Steud.	Fabaceae	Kakawate	tree

Scientific name	Family	Common Name	Habit
Imperata cylindrica (L.) P.Beauv.	Poaceae	cogon	grass
Ipomoea batatas (L.) Lam.	Convolvulaceae	sweet potato	creeper
Knema glomerata(Blanco) Merr.	Myristicaceae	tambalau	tree
Lagerstroemia speciosa (L.) Pers.	Lythraceae	Banaba	tree
Leea manillensis Walp.	Vitaceae	Abang-abang	tree
Leucaena leucocephala (Lam.)de Wit	Fabaceae	Ipil-ipil	tree
Lindenbergia philippensis (Cham. & Schltdl.) Benth.	Orobanchaceae		herb
Macaranga tanarius (L.) Müll.Arg.	Euphorbiaceae	Binunga	tree
Mangifera indica L.	Anacardiaceae	Mango	tree
Manihot esculenta Crantz	Euphorbiaceae	Cassava	shrubs
Melastoma malabathricum L.	Melastomataceae	rhododendron	shrubs
Mikania micrantha Kunth	Asteraceae	Mile-a-minute	vine
Mimosa invisa Colla	Fabaceae	Giant sensitive plant	creeper
Mimosa pudica L.	Fabaceae	Makahiya	creeper
Miscanthus sp	Poaceae		grass
Moringa oleifera Lam.	Moringaceae	Malungai	tree
Muntingia calabura L.	Muntingiaceae	Aratilis	tree
Mussaenda philippica A.Rich.	Rubiaceae	Kahoy dalaga	shrubs
Homalanthus populneus (Geiseler) Pax	Euphorbiaceae	Balanti	tree
Panicum sp.	Poaceae		grass
Parkia timoriana (DC.)Merr.	Fabaceae	Kupang	tree
Parasponia rugosa Blume	Ulmaceae		tree
Passiflora edulis Sims	Passifloraceae	Passion fruit	vine
*Passiflora foetida*L.	Passifloraceae	Kurunggut	vine
Persea americana Mill.	Lauraceae	avocado	tree
Phyllanthus amarus Schumach. & Thonn.	Fabaceae	sampasamplukan	shrubs
Ptychosperma macarthurii H.Wendl.	Arecaceae	McArthur's Palm	shrubs
Phyllanthus sp.	Fabaceae		shrubs
*Pinus merkusii*Jungh. & de Vriese	Pinaceae	Mindoro pine	tree
Pithecellobium dulce (Roxb.)Benth.	Fabaceae	Kamachile	tree

Scientific name	Family	Common Name	Habit
Podocarpus costalis C. Presl	Podocarpaceae		tree
Poikilospermum suaveolens (Blume) Merr.		hanopol	vine
Pouteria rivicoa (C.F.Gaertn.) Ducke	Sapotaceae	Tiesa	tree
Portulaca oleraceae L.	Portulacaceae	Ulasiman	herb
Premna odorata Blanco	Verbenaceae	Alagaw	tree
Psidium guajava L.	Myrtaceae	Guava	tree
Pterocarpus indicus Willd.	Fabaceae	Narra	tree
Pterospermum sp	Malvaceae		tree
Ptychosperma macarthurii (H.Wendl. ex H.J.Veitch) H.Wendl. ex Hook.f.	Arecaceae	Mac Arthurs palm	palm
Robus sp.	Rosaceae	Wild Strawberry	shrubs
Samanea saman (Jacq.) Merr.	Fabaceae	Rain tree	tree
Sandoricum koetjape Merr.	Meliaceae	Santol	tree
Schizostachyum lumampao (Blanco) Merr.	Poaceae	Boho	grass
Senna spectabilis(DC.) H.S.Irwin & Barneby	Fabaceae	Anchoan dilau	tree
Shorea polysperma (Blanco) Merr.	Dipterocarpaceae	Tanguile	tree
*Stachytarpheta jamaicensis(*L.) Vahl	Verbenaceae	Kandikandilaan	shrubs
Streblus asper Lour.	Moraceae	Kalyos	tree
Swietenia macrophylla King	Meliaceae	Large leaf mahogany	tree
Syzygium cumini (L.) Skeels	Myrtaceae	Duhat	tree
Tabernaemontana pandadaqui Prof.	Apocynaceae	Pandakaki	shrubs
Tacca palmata Blume	Taccaceae	Payung-payungan	herb
Tamarindus indica L.	Fabaceae	Sampalok	tree
Terminalia catappa L.	Combretaceae	Talisai	tree
Terminalia foetidissima Griff.	Combretaceae	Talisay gubat	tree
Themeda arundinacea (Roxb.) A.Camus	Poaceae	tarlac grass	grass
Trema orientalis (L.) Blume	Ulmaceae	Anabiyong	tree

Scientific name	Family	Common Name	Habit
Vitex parviflora A.Juss.	Lamiaceae	Molave	tree
Vitex trifolia var. trifolia (Blanco) Ngan	Lamiaceae	Laniti	tree
Vitex negundo L.	Lamiaceae	Lagundi	tree

Family Fabaceae is the most represented family with nineteen (19) genera, while Families Poaceae and Moraceae have nine (9). Dominance of Family Fabaceae is observed in many types of ecosystems since the family is not limited to a single growth habit. *Table 69* shows the distribution of number of species among families observed on the site.

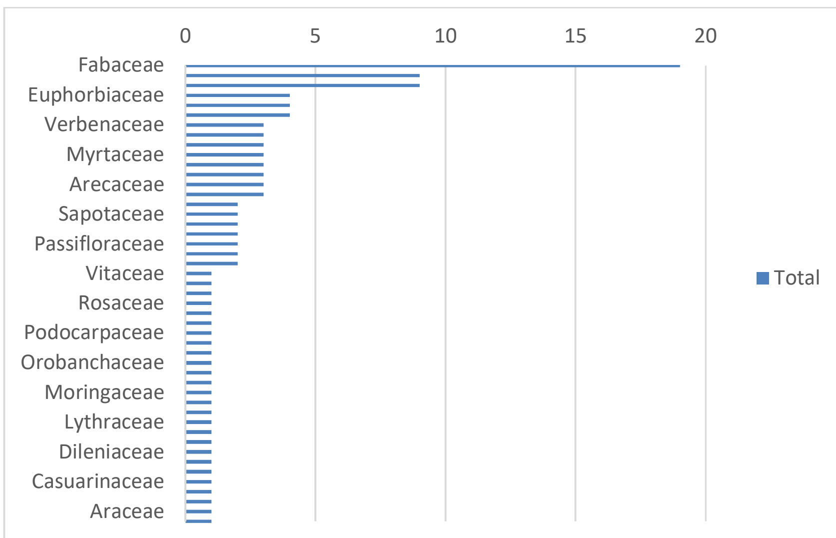


Figure 48 - Number of species per families observed on the site.

Based on the plots assessed, the most abundant tree species is Binayuyo (*Antidesma ghaesembilla*) of Family Phyllanthaceae with 18 individuals recorded. Mangga (*Mangifera indica* L.) of Family Sapindaceae and Kakawate (*Gliricidia sepium* L.) of Family Fabaceae are the next most abundant species with eleven (11) recorded individuals.

Species diversity described by Shannon-Weiner Index (H') of the area differs across the six (6) established stations. The values range from Low to High diversity based on the Fernando's Biodiversity Scale. Transect 3 (T3) registers a High diversity (H'=3.08), which is also the highest among the assessed areas. Varied diversity indices are expected since multiple vegetative community were observed on the sampling site.

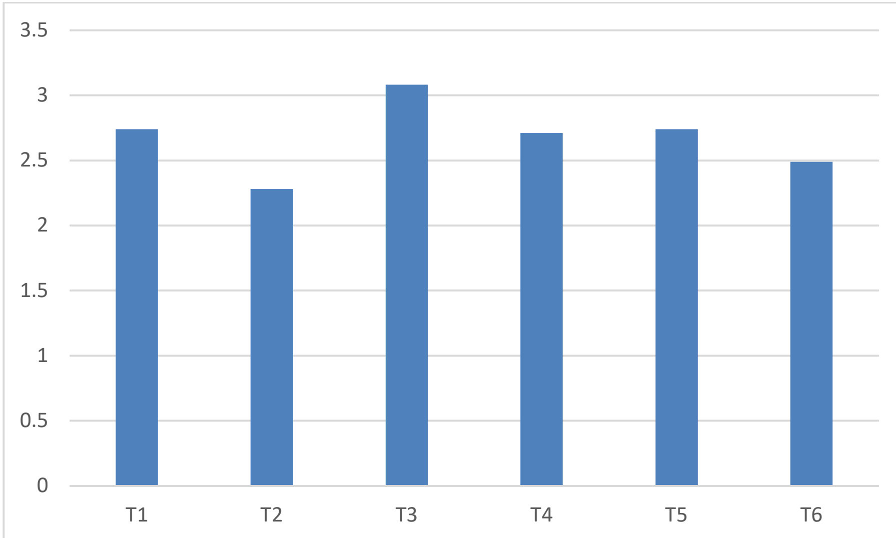


Figure 49 - Shannon-Weiner Diversity Index (H') of the established transects.

Contrary to the varied diversity indices, species evenness (J') as described by Pielou's Index were uniform all throughout the assessed transects. All of the values obtained registers a Very High species evenness, indicating that species are present in uniform distribution and dominance of certain species is not highly significant. Transect 3 and Transect 6 (both J'=0.87) registers the highest species evenness.

Table 71 shows the complete values of the computed and Pielou's species evenness (J').

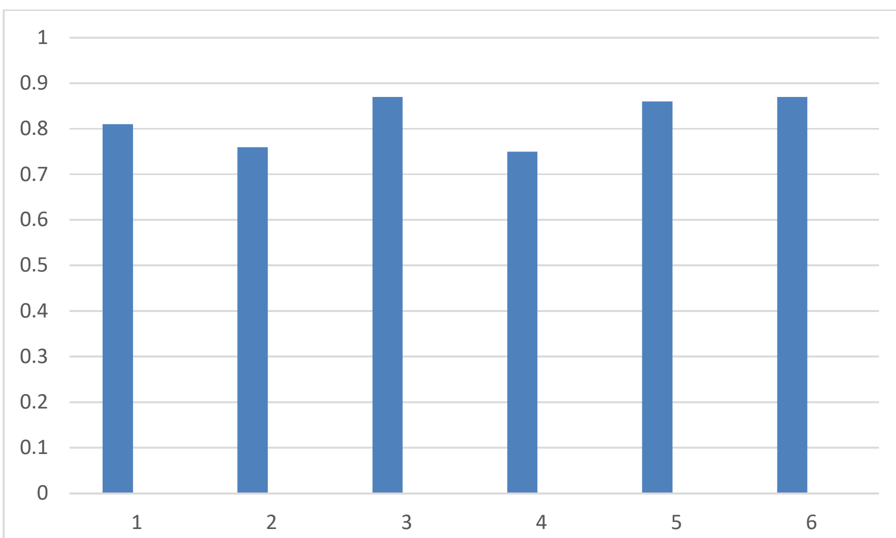


Figure 50 - Computed Pielou's Species Evennes of the established transects.

Importance Values (IVs) of the trees intercepted in all six (6) stations were also analyzed. The respective IVs of the plants were the summation of their computed Relative Density, Relative Frequency and Relative Dominance. From the results, Mangga (*M. indica* L) has the highest recorded IV of 25%. The high IV of Mangga is accounted mainly to the very high Relative Dominance of the said species as compared to the values of other plants. The wide girths of the mango trees assessed gave the species a very high basal area thereby resulting to the species' dominance. It is followed by Binayuyo (*A. ghaesembilla* Gaertn) with 21%. Kakawate (*G. sepium* L) and Ipil-ipil (*L. leucocaepala*) are relatively smaller trees but also managed to be among the plants with the highest IVs (IV=16%), mainly because of their abundance in the transects established. Banaba (*L. speciosa*) of Family Lythraceae is also at the top of the list of the floral species (IV=15%), mainly because of its frequency. It appeared in the four transects (T2, T3, T4, T5) and got a Relative Frequency of 6.67%, which is the highest among the plants assessed.

Table 31 - List of the species with the highest Importance Values (IVs).

Scientific name	Common Name	Importance Value (%)
***Mangifera indica* L.**	Mangga	25
***Antidesma ghaesembilla* Gaertn.**	Binayuyo	21
***Leaucaena leucocaepa* Lam. De Wit**	Ipil-ipil	16
***Gliciridia sepium* Jacq. Steud.**	Kakawate	16
***Lagerstroemia speciosa* (L.) Pers.**	Banaba	15
***Syzygium cumini* (L.) Skeels**	Duhat	14
***Vitex parviflora* A.Juss.**	Molave	13
***Casuarina equisitifolia* L.**	Agoho	11
***Pithecellobium dulce* (Roxb.)Benth.**	Kamachile	11
***Ficus benjamina* L.**	Balete	10
***Premna odorata* L.**	Anagaw	10
***Swietenia macrophylla* King**	Mahogany	10

Understory and Regenerants

Assessment of the smaller plants such as understory species and regenerants were also conducted inside the established plots. Majority of these species includes shrubs, grasses, herbs, palms, vines and ferns. Assessment of these smaller plants is essential particularly in predicting what species will probably dominate the area through time. It will also give an idea on what species have a higher chance of maintaining their stands. *Table 32* shows the most dominant understory and regenerant species observed in the area.

Table 32 - Dominant non-tree species and regenerants observed on the understory or creeping on other tree species.

Species	Common Name	Transects observed
Understory species		
Stachytarpheta jamaicensis (L.) Vahl	Kandi-kandilaan	1,2,3,4,5,6
Melastoma malabatrichium L.	Rhododendron	1,2,3,4,6
*Chromolaena odorata (*L.) R.M.King & H.Rob.	Hagonoy	1,2,3,4
Desmodium turtuosum (Sw.)DC.		1,4,5,6
Tacca palmate Blume	Payung-payungan	1,2,4
Canavalia cathartica Thouars	Palang-palang	1,2,3
Clitoria pubescens (Benth.) E.H.L.Krause	pukinggang-baging	1,4,5
Passiflora foetida L.	Kurunggut	1,2,5
Robus sp	Wild strawberry	2,4
Regenerants		
Broussonetia papyrifera	Paper mulberry	2,3,4,5
Alstonia macrophylla Wall. ex G.Don	Batino	2,3,5,6
Casuarina equisetifolia L.	Agoho	1,2,5,6
Ficus septica Burm. fil.	Ficus septica	1,4,5
Mangifera indica L.	Mango	2,4,5
Acacia mangium L.	Mangium	1,4,6

Shrubs like Kandi-kandilaan (*Stachytarpheta jamaicensis* L.) of Family Verbenaceae is one of the most dominant among the species observed. A known resident of mineralized area, *Melastoma malabatrichium* of Family Melastomataceae is also recorded on the area.

Herbs such as *Chromolaena odorata, Desmodium turtuosum* and *Tacca palmata* Blume are the most common species which were recorded in at least three of the six stations assessed. Palms, which are members of Family Arecaeae were also observed among the plots. Some of the palms observed are the members of genus *Caryota* or fishtail palms.

Herbaceous vines such as *Canavalia cathartica* Thouars, *Clitoria pubescens* E.H.L.Krause, and *Passiflora foetida* L are observed on either the forest floor, or creeping over stems and trunks. The woody vine Hanopol, *Poikilospermum suaveolens* Merr. is located on two plots (T4 and T5).

Figure 51- Herb species, T. palmata Blume observed on the rocky substrate of T1 (left) and regenerant of paper mulberry (B.papyrifera)

Ferns are also observed on the area. Palaypay (*Acrosticum aureum* L.) and Kaikai (*Adiantum philippense* L.) are observed in four out of six assessed area.

Regenerants of larger trees observed on the plots were also listed. It was observed that regenerants also vary across the stations. In some area their dominance reflect what is the most dominant tree on the specific station is. For example, in T1, Agoho regenerants are the most common. This is in congruence with the findings that Agoho is also the most common tree species in transect 1. However, this trend is not applicable to every station. In T2, manga (*M. indica* L.) is the most common, but the most common regenerant species is Paper Mulberry (*Broussonetia papyrifera*) whose invasive characteristics in the country are being studied.A comparison of the abundance of floral species according to their growth habit is listed on *Figure 52*

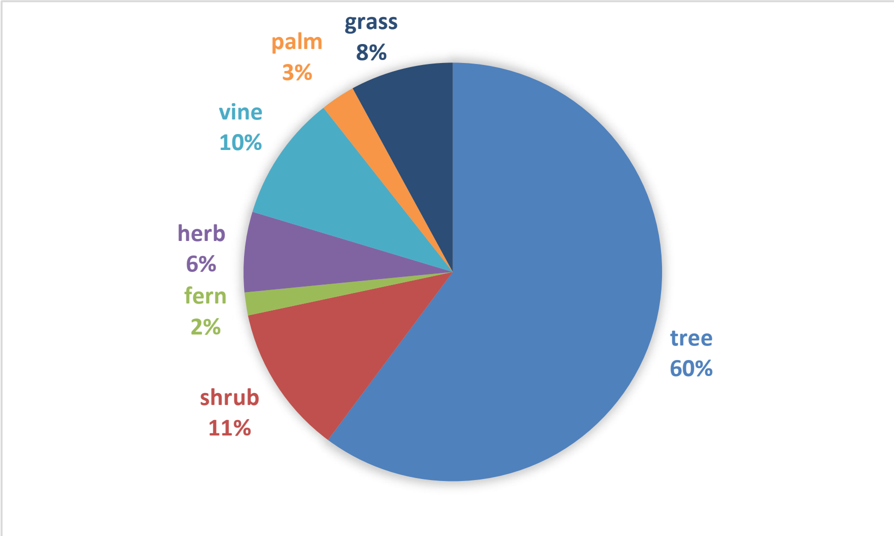


Figure 52 - Growth habit of observed plant species.

<u>*Endemicity and Vulnerability*</u>

One of the main considerations in assessment and monitoring of floral species is the presence of flagship species or those with conservation values. To assess this, determination of the species residency and vulnerability was done. Based on literature review of the range of all the species observed, it was found that majority of the species (67 species) intercepted were indigenous species, as shown in *Table 70***.** These species are locally present, but was also present in other parts of the world. Thirty-three (33) species were exotics. These are the species that are not originally part of the Philippine flora but were introduced to adopt in the Philippine setting; some of which pose significant threats because of their possible invasive characteristics. Only two (2) species were endemic to the country, Katmon (*D. luzoniensis* Vidal) and Is-is (*Ficus ulmifolia* Lam).

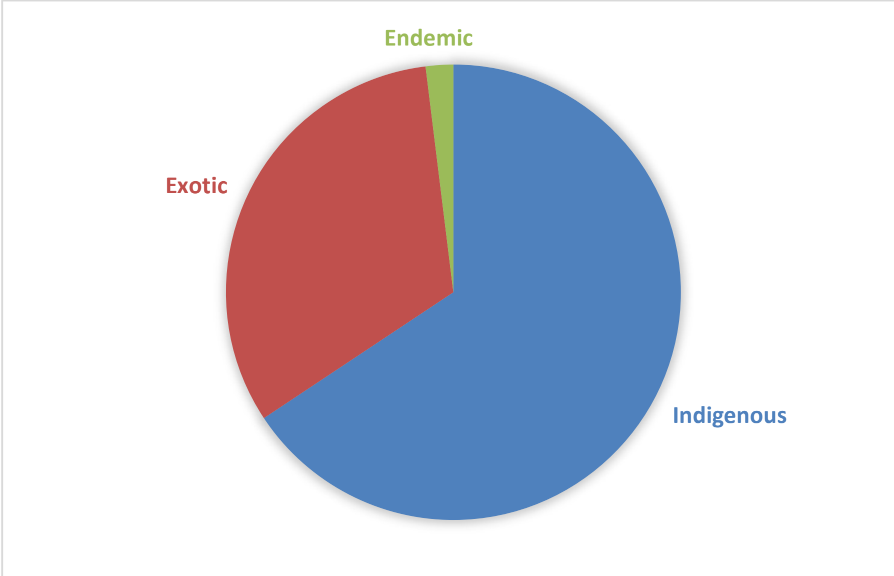


Figure 53 - Comparison of the abundance of indigenous, exotic and endemic species found on the study site.

Figure 54 - The endemic species, Katmon (D. luzoniensis), was observed on its flowering season during the observation on the study site.

Other vulnerable species, based on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, includes other tree species that were observed are also tree species.

Table 33 - List of internationally-vulnerable species based on IUCN

Scientific name	Common name	Conservation Status
Artocarpus blancoi (Elmer) Merr.	Antipolo/Tipolo	Vulnerable
Dillenia luzoniensis Vid.Martelli	Katmon	Vulnerable
Ficus ulmifolia Lam.	Isis	Vulnerable
Pinus merkusii Jungh. & de Vriese	Mindoro Pine	Vulnerable
Podocarpus costalis C. Presl	Arius	Endangered
Pterocarpus indicus Willd.	Narra	Vulnerable
Swietenia macrophylla King	Large leaf Mahogany	Vulnerable
Vitex parviflora A.Juss.	Molave	Vulnerable

Arius (*Podocarpus costalis* C. Presl) is found with a single stand in T1. It is considered as an endangered species because of the continuous depletion of its population due to over-utilization. This species is known for its horticultural value and the exploitation of the species became a threat to its population. Its biogeographic range also became highly fragmented.

Ethnobotany

Local usages of the different plants observed on the sites were listed to see how the nearby community utilize the forest. Of the species recorded, most of the usable plants exhibit medicinal properties while other species are used as food and for utilities. *Table 34* shows the common plants and their respective uses.

Table 34 -List of some of the common plants with ethnobotanical importance observed on the study site.

Scientific name	Common name	Known uses
Alstonia macrophylla Wall. ex G.Don	Batino	Medicinal- Antibacterial, anti-inflammatory

Scientific name	Common name	Known uses
Alstonia scholaris (L.) R.Br.	Dita	Medicinal- cures Fever, dysentery
*Anacardium occidentale*L.	Kasuy	Fruit
Antidesma bunius (L.) Spreng.	Bignai	Fruit, Medicinal-Anti-oxidant, Used for wine making
Antidesma ghaesambilla Gaertn	Binayuyo	Fruit, Medicinal-Anti oxidant
Artocarpus heterophyllus Lam.	Nangka	Fruit
Averrhoa bilimbi L.	kamias	Fruit
Bauhinia malabarica Roxb.	Alibangbang	Medicinal- cures dysentery
Blumea balsamifera L.	Sambong	Medicinal-diuretic
Cassythia filiformis L.	Malabuhok	Medicinal- cures headache
Dillenia luzoniensis Vid.Martelli	Katmon	fruit/timber
Diospyros discolor Willd.	Mabolo	endangered
Eucalyptus deglupta Bl.	Bagras	Timber
Euphorbia hirta L.	Tawa-tawa	Medicinal- cures asthma
Gliricidia sepium Jacq. Steud.	Kakawate	Medicinal- Antibacterial
Leucaena leucocephala (Lam.)de Wit	Ipil-ipil	Medicinal- cures diarrhea, hypertension
Mangifera indica L.	Mango	Medicinal- cures diarrhea, hypertension
Morinda citrifolia L.	Apatot	Medicinal- cures nausea, convulsions
Homalanthus populneus (Geiseler) Pax	Balanti	Medicinal- cures diarrhea
Pterocarpus indicus Willd.	Narra	Medicinal- Anti-inflammatory
Sandoricum koetjape Merr.	Santol	Fruit

Scientific name	Common name	Known uses
SSwietenia macrophylla King	Large leaf mahogany	Timber

A variety of medicinal plants were observed on the site. Plants that cure diarrhea and dysentery such as Batino (*A. macrophylla* Wall. ex G.Don) and Alibangbang (*Bauhinia malabarica* Roxb) were found on the sites. The second most dominant plant based on its IV (as discussed earlier), Binayuyo (*A. ghaesambilla* Gaertn) and its Bignay (*A. bunius* Spreng) also exhibits high anti-oxidant contents.

Herbs such as tawa-tawa (*Euphorbia hirta* L.) is found on the understory and is considered as a good anti-inflammatory agent. This plant is declared by the Department of Health (DOH) as one of the 10 most common medicinal plants in the Philippines. Other plants on this list that were found on the sites include Sambong (*Blumea balsamifera* L.*)* which is used as a diuretic; Bayabas (*Psidium guajava* L.) which is used for its anti-microbial properties; and Lagundi (*V. negundo* L.) which is a popular cure for coughs and pulmonary diseases. Banaba (*L. speciosa*) which ranks fifth in terms of its IV also has medicinal properties being utilized by the community. Tea were made from its leaves and barks and is known to resist diabetes and urinary tract infections.

Fruiting trees were also observed in the area. As discussed earlier, Mangga (*M. indica* L.), a known fruiting tree, has the highest IV among the plants assessed. As observed on the area, different variety of manga such as Indian, Apple-Mango, and Piko were present on the site. This fruit is one of the major agricultural product of Zambales. Another fruiting tree that is dominant on the area is Duhat (*S. cumini* Skeels). Stands of this trees vary from 20-m tall trees to small trees of 4 to 5 cm height. Almost all of the intercepted individuals of this species were fruiting by the time of the assessment. Other fruiting trees includes Lukban (*Citrus maxima* Osbeck), Avocado (*Persea americana* Mill.), Guava (*P. guajava* L.), and Sampaloc (*Tamarindus indicus* L.).

Timber species were also found on the area. Some of the species of hardwood is Kamagong (*D. blancoi*), Mahogany (*S. macrophylla* King) and Molave (*V. parviflora* Ajuss). Non-timber forest products such as bamboo stands were also present in the area. The species Buho (*Schizostachyum lumampao* (Blanco) Merr.) were found on the T1, T5 and T6. Also, it was observed in the site that the local communities are utilizing the smaller trees with about DBH<10cm in construction of their household**.**Charcoal-making is also evident in the area. Two areas with charcoal were observed during the assessment.

Figure 55 - Charcoal-making site observed near T2 (right) and bundles of mixed small-tree stands near T5 being utilized for household constructions.

2.1.5.1.3 Possible Threats due to the proposed Project

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 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.

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.

2.1.5.1.4 Impact Management

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, Arius (*Podacarpus costalis*) that was observed on T1 can be a source of material for further propagation of the species. Other vulnerable species must also be taken into consideration in the nursery operations aside from the reforestation species.

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. 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.

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 are capable of reducing water's flow velocity and diverting surface run-off.[10]

Bamboo species are also known to be effective in mine rehabilitation. It is noted that Boho, (*S. lumampao* (Blanco) Merr) was found in abundance in some of the studied transects. Bamboo species are noted for their stability and dense root systems.

2.1.5.2 Fauna

2.1.5.2.1 Methodology

Terrestrial fauna which include birds, mammals, amphibians and reptiles was assessed from June 9-11, 2018 within the proposed mining area in Candelaria, Zambales. The survey was carried out in five transects in accordance with the plots for vegetation assessment. The sites chosen varies from grassland, forest edge, secondary growth and riparian forests. The GPS coordinates, short description and dominant plant species in each transects are described in *Table 35*.

For the avifaunal survey, transect walks of ~2 km per transect were conducted twice daily during the early morning and late afternoon. This was done along existing road or trail way which allow the observer to identify bird species encountered. Species that were seen or heard were identified, photographed (if possible), counted and described based on its distinct features. Identification was further validated using various bird field guides such as Kennedy et al. (2000). Ethnobiological accounts of trail guide and local community met along the way were also noted. All species were tabulated in terms of feeding role, distribution and conservation status. Diversity indices as well as other analysis was done using Paleontological Statistics (PAST) 3.10. Cluster analysis was done to determine the similarity of the transects in terms of bird species abundance. SHE analysis was further made to characterize the computed diversity indices in each transect.

Mist nets were also used to validate the occurrence of cryptic, shy, low flying and non-land bird species as well as volant mammals within the transects. Each net made up nylon with pouches, measuring 2 x 9 meters, were set up as well and checked regularly to determine the catch. Netting success was determined by determining the number of catch and number of trap days and trap nights.

Sampling for Murids (rats and mice) were done using live traps with roasted coconut and peanut butter as bait. Traps were set in locations where the mammals are suspected to pass through such as near ground holes, fallen logs and thick litter fall. Opportunistic sampling and ethno-biological survey were also done for other groups of terrestrial fauna such as mammals, reptiles and amphibians.

Table 35 - Site Description of each transect

Transect	Coordinates	Site Description
1	15°39'18.10"N 119°58'5.07"E to 15°39'7.21"N 119°57'38.29"E	Closed secondary forest dominated by mahogany (*Swietenia macrophylla* Jacq), white lauan (*Shorea contorta* S. vidal) and binunga (*Macaranga tanarius* L. Muell.-Arg.)
2	15°40'3.70"N 119°57'57.95"E to 15°39'39.98"N 119°57'40.09"E	Secondary growth riparian forest passing through a river system.
3	15°35'52.39"N 120° 0'15.50"E to 15°35'40.10"N 119°59'40.93"E	Grassland area with stunted patches of forests. Dominant species are *Parasponia rugosa* Blume and *Acacia mangium* Willd

Transect	Coordinates	Site Description
4	15°37'48.30"N 119°58'41.70"E to 15°37'37.46"N 119°58'9.88"E	Secondary forest edge near a cave with trees measuring up to 20m.
5	15°36'49.89"N 119°58'4.84"E to 15°36'22.03"N 119°57'48.04"E	Patches of trees adjacent to an agricultural area and human settlement; Dominant species includes kakauate (*Gliciredia sepium* Jacq.) and Kamuning (*Murraya paniculata* Jacq.)

2.1.5.2.2 Result and Discussion

2.1.5.2.2.1 Avifauna diversity

A total of 40 species belonging to 28 taxonomic families of birds were observed through transect walks, mist netting and ethno-biological accounts. One of the notable species that was observed include the endemic Philippine Duck (*Anas luzonica*) which has been categorized as Vulnerable by the International Union for the Conservation of Nature (IUCN) and DENR Administrative Order (DAO) 2004-15. According to IUCN, Vulnerable species are likely to become endangered unless the circumstances that are threatening its survival and reproduction improve. Vulnerability is said to be predominantly caused by hunting and habitat loss or destruction of the species' home. On the other hand, some of the identified species which were noted by the Convention on International Trade in Endangered Species (CITES) as Appendix II are: Brahminy Kite (*Haliastur indus*), Guaiabero (*Bolbopsittacus lunulatus*) and Philippine Hanging Parrot (*Loriculus philippensis*). 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.

Out of the 28 families of birds, Columbidae and Alcedinidae were the most well represented family in terms of species richness. Four species were noted under Alcedinidae (family of kingfishers) while three for Columbidae (family of fruit doves). This is expected since some transects are near bodies of water such as streams/rivers and are also abundant with fruit bearing plants and trees. Six families were represented by two species each such as Cuculidae (Coucals and Malkohas), Dicaeidae (Flowerpeckers), Meropidae (Bee-eaters), Muscicapidae (Flycatchers and Bushchats), Psittacidae (Parrots) and Sturnidae (Coletos and Mynas). The rest of the families have only one species recorded. Some of the observed and photographed bird species in the area are shown in *Figure 56*.

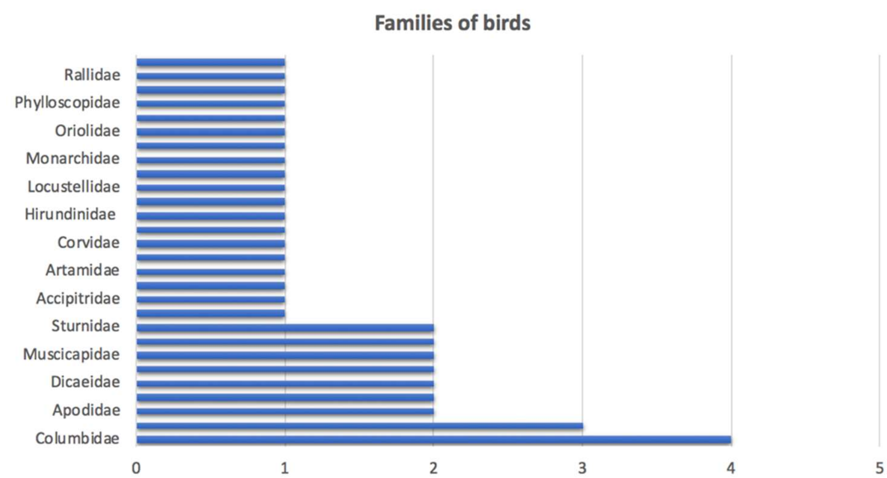


Figure 56 - Number of species observed per family of birds.

In terms of bird species distribution, majority of the observed species (68%) are categorized as resident species (*Figure 26*), meaning, they occur in the Philippines as well as in other parts of the world. About 11 species (27%) of observed bird species are endemic in the country which includes the Philippine duck. Three endemic species have been found to have a restricted range of occurrence such as: Scale-feathered Malkoha (*Lepidogrammus cumingi*), a Luzon Island endemic and Guaiabero and Pygmy Swiftlet (*Collocalia troglodytes*) which are only found in the islands of Luzon, Samar, Leyte and Mindanao.

Table 36 - List of observed avifaunal species through transect walks, mist netting and ethnobiological accounts.

No.	Family	Scientific Name	Common Name	Feeding role[a]	Distribution[b]	IUCN Status[c]	CITES	DAO 2004-15	Observation	Transects present
1	Acanthizidae	*Gerygone sulphurea* (Wallace, 1864)	Golden-bellied Gerygone	Ins	R	LC	-	-	Heard	1
2	Accipitridae	*Haliastur indus* (Boddaert, 1783)	Brahminy Kite	Car	R	LC	App. II	-	Seen	1,3
4	Alcedinidae	*Alcedo atthis* (Linnaeus, 1758)	Common Kingfisher	Pis	M	LC	-	-	Seen	5
3	Alcedinidae	*Todiramphus chloris* (Boddaert, 1783)	White-collared kingfisher	Pis	R	LC	-	-	Seen, heard	1,2,3,4,5
5	Alcedinidae	*Halcyon gularis* (Kuhl, 1820)	White-throated kingfisher	Ins	R	LC	-	-	Seen, Captured	2
6	Anatidae	*Anas luzonica* (Fraser, 1839)	Philippine Duck	Omn	E	Vul	-	Vul	Seen	1,5
7	Apodidae	*Collocalia esculenta* (Linnaeus, 1758)	Glossy Swiftlet	Ins	R	LC	-	-	Seen	1,2,3,4,5
8	Apodidae	*Collocalia troglodytes* (Gray, 1845)	Pygmy swiftlet	Ins	R	LC	-	-	Seen	1,2,4,5
9	Artamidae	*Artamus leucoryn* (Linnaeus, 1771)	White-breasted woodswallow	Ins	R	LC	-	-	Seen	3,5

No.	Family	Scientific Name	Common Name	Feeding role[a]	Distribution[b]	IUCN Status[c]	CITES	DAO 2004-15	Observation	Transects present
10	Cisticolidae	*Orthotomus ruficeps* (Lesson, 1830)	Philippine tailorbird	Ins	E	LC	-	-	Heard	2
14	Columbidae	*Streptopelia bitorquata* (Temminck, 1809)	Island collared dove	Gran	R	LC	-	-	Heard	4
13	Columbidae	*Streptopelia tranquebarica* (Hermann, 1804)	Red turtle dove	Gran	R	LC	-	-	Seen, Heard	1,2,3,4
11	Columbidae	*Phapitreron leucotis* (Temminck, 1823)	White-eared brown dove	Fru	E	LC	-	-	Heard	1,2,4
12	Columbidae	*Geopelia striata* (Linnaeus, 1766)	Zebra dove	Gran	R	LC	-	-	Seen, Heard	1
15	Corvidae	*Corvus macrorhynchos* (Wagler, 1827)	Large-billed crow	Omn	R	LC	-	-	Seen, Heard	4
16	Cuculidae	*Centropus bengalensis* (Gmelin, 1788)	Lesser coucal	Ins	R	LC	-	-	Seen, Heard	2
17	Cuculidae	*Lepidogrammus cumingi* (Fraser, 1839)	Scale-feathered malkoha	Ins	E	LC	-	-	Seen	4
18	Dicaeidae	*Dicaeum bicolor* (Bourns & Worcester, 1894)	Bicolored flowerpecker	Nec	E	LC	-	-	Heard	1,2,3,4

No.	Family	Scientific Name	Common Name	Feeding role[a]	Distribution[b]	IUCN Status[c]	CITES	DAO 2004-15	Observation	Transects present
19	Dicaeidae	*Dicaeum hypoleucum* (Sharpe, 1876)	Buzzing flowerpecker	Nec	E	LC	-	-	Heard	1
20	Estrildidae	*Lonchura atricapilla* (Vieillot, 1807)	Chestnut munia	Gran	R	LC	-	-	Seen	2
21	Hirundinidae	*Hirundo tahitica* (Gmelin, 1789)	Pacific swallow	Ins	R	LC	-	-	Seen	1
22	Laniidae	*Lanius cristatus* (Linnaeus, 1758)	Brown Shrike	Ins	M	LC	-	-	Seen, Heard	3
23	Locustellidae	*Megalurus palustris* (Horsfield, 1821)	Striated grassbird	Ins	R	LC	-	-	Seen	2,3,5
24	Megalaimidae	*Psilopogon haemacephalus* (Müller, 1776)	Coppersmith barbet	Fru	R	LC	-	-	Heard	1
25	Meropidae	*Merops philippinus* (Linnaeus, 1766)	Blue-tailed bee-eater	Ins	R	LC	-	-	Seen	1,2,3,4,5
26	Meropidae	*Merops viridis* (Linnaeus, 1758)	Blue-throated bee-eater	Ins	R	LC	-	-	Seen	1,2,3,4
27	Monarchidae	*Hypothymis azurea* (Boddaert, 1783)	Black-naped monarch	Ins	R	LC	-	-	Captured	3

No.	Family	Scientific Name	Common Name	Feeding role[a]	Distribution[b]	IUCN Status[c]	CITES	DAO 2004-15	Observation	Transects present
29	Muscicapidae	*Cyornis rufigastra* (Raffles, 1822)	Mangrove blue flycatcher	Ins	R	LC	-	-	Captured	4
28	Muscicapidae	*Saxicola caprata* (Linnaeus, 1766)	Pied bushchat	Ins	R	LC	-	-	Seen	3
30	Nectariniidae	*Cinnyris jugularis* (Linnaeus, 1766)	Olive-backed sunbird	Nec	R	LC	-	-	Seen	1,2,4
31	Oriolidae	*Oriolus chinensis* Linnaeus, 1766	Black-naped oriole	Ins	R	LC	-	-	Seen, Heard	1,2,3,4
32	Passeridae	*Passer montanus* (Linnaeus, 1758)	Eurasian tree sparrow	Gran	R	LC	-	-	Seen	3
33	Phylloscopidae	*Phylloscopus borealis* (Blasius, 1858)	Arctic warbler	Ins	R	LC	-	-	Seen, Heard	3,5
35	Psittacidae	*Bolbopsittacus lunulatus* (Scopoli, 1786)	Guaiabero	Gran	E	LC	App. II	-	Ethno	1
34	Psittacidae	*Loriculus philippensis* (Müller, 1776)	Philippine hanging parrot	Fru	E	LC	App. II	-	Seen	1
36	Pycnonotidae	*Pycnonotus goiavier* (Scopoli, 1786)	Yellow-vented bulbul	Ins	R	LC	-	-	Seen, Captured	1,2,3,4
37	Rallidae	*Hypotaenidia torquata* (Linnaeus, 1766)	Barred rail	Ins	R	LC	-	-	Seen	2,5

No.	Family	Scientific Name	Common Name	Feeding role[a]	Distribution[b]	IUCN Status[c]	CITES	DAO 2004-15	Observation	Transects present
38	Rhipiduridae	*Rhipidura nigritorquis* (Vigors, 1831)	Philippine pied fantail	Ins	E	LC	-	-	Seen	2
39	Sturnidae	*Sarcops calvus* (Linnaeus, 1766)	Coleto	Omn	E	LC	-	-	Seen	1
40	Sturnidae	*Acridotheres cristatellus* (Linnaeus, 1766)	Crested myna	Omn	R	LC	-	-	Seen	2

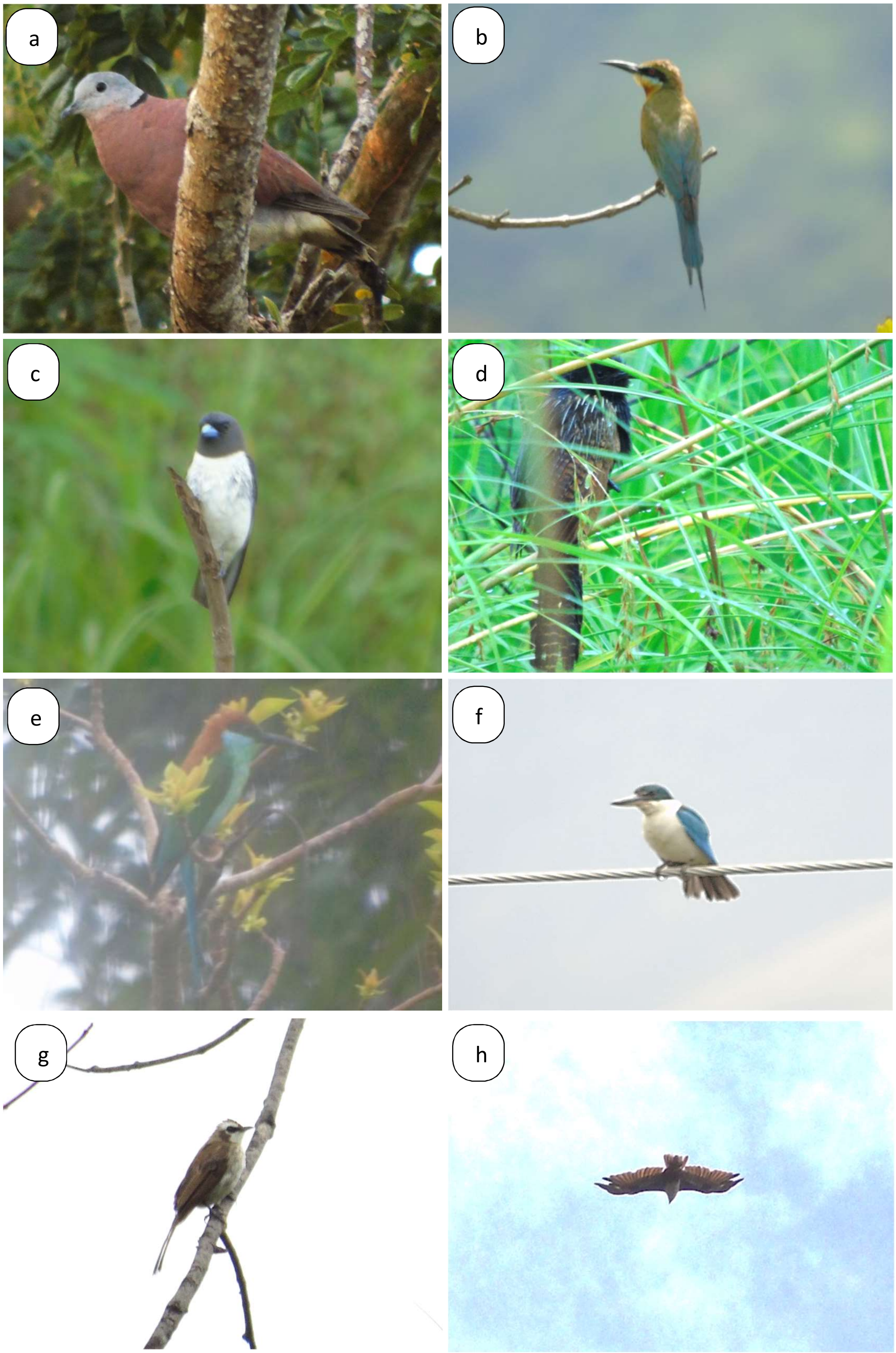


Figure 57 - Some of the observed bird species: a.) Red turtle dove, b.) Blue-tailed bee-eater, c.) White-breasted woodswallow, d.) Lesser coucal, e.) Blue-throated bee-eater, f.) White-collared kingfisher, g.) Yellow-vented bulbul and h.) Brahminy kite.

Other observed endemic species worth mentioning are: Philippine Hanging Parrot, Philippine Tailorbird (*Orthotomus ruficeps*), White-eared Brown Dove (*Phapitreron leucotis*), and Coleto (*Sarcops calvus*). The said endemic species are known to commonly occur in different types of habitats in the Philippines from open country, grasslands and secondary growth forests (Kennedy et al. 2000). Furthermore, this high level of endemicity underlines the importance of the area as a refuge for bird species that are only found in the Philippines. Only two species were noted to be migratory: Brown Shrike (*Lanius cristatus*) and Common Kingfisher (*Alcedo atthis*). These species usually migrate overwinter across Asia such as China, Japan, Korea, Taiwan and even Russia (BirdLife International, 2016).

Majority of the observed bird species were categorized as generally insectivores (68%) which feed on insects, spiders and other invertebrates. Insectivorous species are worth noting because according to a study by Sekercioglu et al. (2001), understory insectivorous birds are sensitive to habitat fragmentation because of their limited dispersal capabilities across fragmented landscapes. Also occurring at the sampling sites are granivores (15%) or seed and grain consumers and omnivores (10%) which eat both plant materials and animals such as insects and other invertebrates. Only one (1) raptorial species was noted to be a carnivore, the Brahminy kite. This bird of prey feed on a variety of small animals such as reptiles, birds, crustaceans, fish and amphibians (Ridell, 2017). It is also essential to note that there are nectarivore species (8%) which are important pollinators and frugivore species (7%) which may signify chances for seed dispersal of about 70-90% of rainforest tree species especially of native species (Moran et al. 2008).

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). Transect 1 which was noted to be abundant with *Syzigium cumini* trees, harbor the most number of frugivorous bird species such as doves. The predominantly grassland area in transect 3 are abundant with conspicuous seed eating species such as striated grassbird (*Megalurus palustris*) and chestnut munia (*Lonchura atricapilla*). Different kingfishers such as the white-throated kingfisher (*Halcyon gularis*) which are known to occur near rivers/streams was caught in a mist net within the riparian forest in transect 2. The lowest number of species (10 species) observed was in transect 5 which is characterized as near agricultural fields and human settlement.

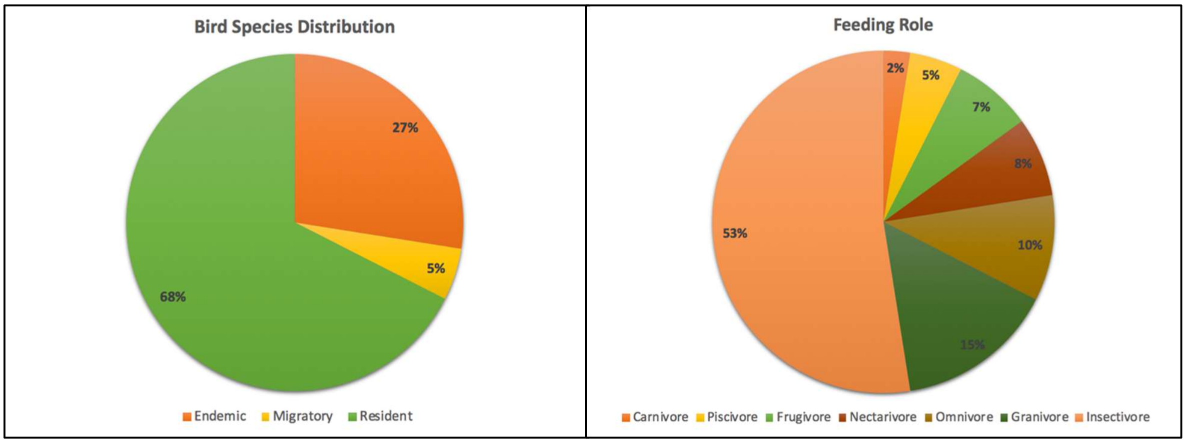


Figure 58. -Percentage of bird species in terms of distribution (left) and feeding role (right).

A cluster analysis using Bray-Curtis was done to determine the relationship of each transect in terms of bird species abundance. Results show that at ~50% level of similarity, transects 1, 2 and 4 which are the secondary growth forests have similar bird species composition. Grouped together are transect 3 (grassland area) and transect 5 (agricultural/near human settlement area) which are comprised of conspicuous bird species that are able to tolerate a wide array of habitats such as disturbed open country and even urban areas.

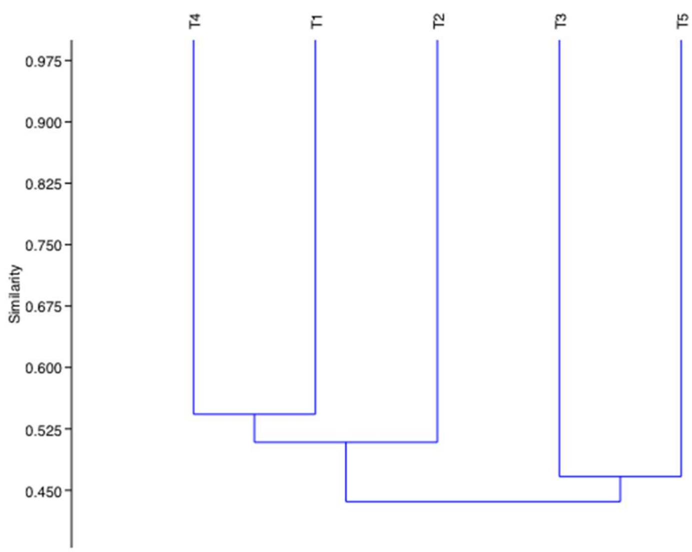
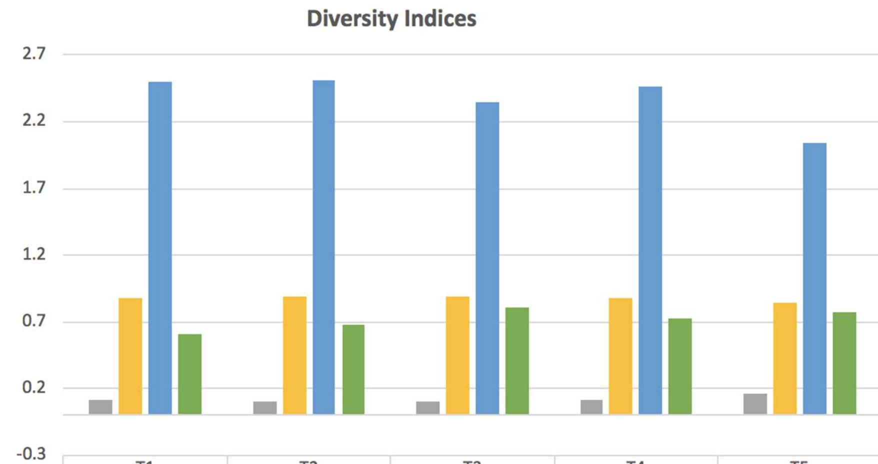


Figure 59 - Cluster analysis of bird species abundance in each transect.

Based from the values of diversity indices, the effective numbers of species (also termed as the true diversity of the community) were derived. Conversion of diversity indices to their effective numbers of species makes them readily comparable due to similarity in terms of mathematical properties (Baños and Ecuador 2006). The effective numbers of species (ENS) were computed using the formula exp (H') where: H' = Shannon-Weiner index.

The highest ENS were shown in Transects 1 and 2 with values of 12.18 and 12.29 respectively. Both transects are secondary growth forests and are near rivers. Secondary growth forests that have high vegetation diversity support diverse bird species by providing more food sources and habitat. Riparian forests also harbor diverse interior forest birds albeit human disturbed habitats (Azman, 2011; Lopez and Alvarez, 2014). Generally diverse forests are said to provide structural complexity to support a variety of bird species niche. Transect 4, also a secondary forest, has high ENS values (11.68) comparable with the other two mentioned transects. The grassland area (transect 3) also support unique bird species but not as diverse than the previous transects, the ENS value calculated for this transect was 10.43. The least diverse transect is transect 5 (ENS = 7.68) which as mentioned is near human disturbances and has low vegetation diversity. Along this transect, cattle raising is also evident as well as the presence of unpaved trail ways that are subjected to daily influx of both farmers and passersby according to local residents. No mist netting was set along this transect for security purposes.

The Simpson's index is relatively the same for all transects which ranges from 0.84-0.89, indicating low diversity. However, evenness values range from 0.60-0.76 which implies high to very high even distribution and abundance of the species observed in all transects. Highest evenness value was observed in transect 3 which have less dominant species and comparable relative abundances. This is evident with low dominance values in all transects ranging from 0.10-0.15. Diversity indices values are illustrated in *Figure 60*. A SHE analysis was used to account for the contribution or role of each diversity components (species richness, Shannon index and evenness). Results showed that the role of species richness was more important in defining the species diversity than evenness in each transect locations (*Figure 61*).



	T1	T2	T3	T4	T5
Dominance_D	0.1159	0.1061	0.1068	0.1196	0.1587
Simpson_1-D	0.8841	0.8939	0.8932	0.8804	0.8413
Shannon_H	2.5	2.509	2.345	2.458	2.039
Evenness_e^H/S	0.6093	0.6831	0.8025	0.7303	0.7682

Figure 60 - Graphical illustration of diversity indices values for each transect.

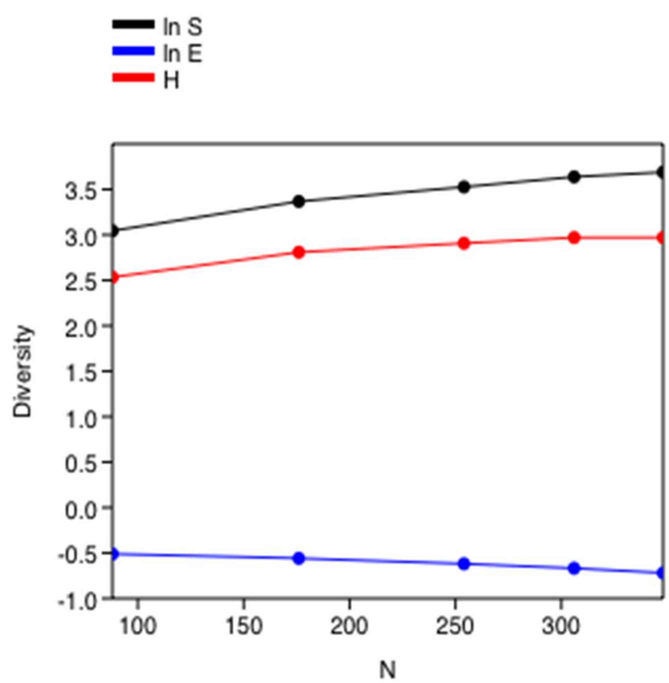


Figure 61 - SHE analysis on the species diversity of bird species at each transect locations.

2.1.5.2.2.2 Volant and Non-Volant Mammals

A total of nine (9) species of volant and non-volant mammals were noted through mist netting, trapping, opportunistic sampling and ethnobiological accounts. There were four species from two families (Hipposideridae and Pteropodidae) of volant mammals (bats) observed. Three of the said species were caught in mist nets which includes: 1.) Diadem Horseshoe-bat (*Hipposideros diadema*), characterized by spots of white hair at the shoulders, 2.) Short-nosed fruit bat (*Cynopterus brachyotis*), with a distinct white coloring at the margin of the ear and 3.) Common Rousette (*Rousettus amplexicaudatus*), having an elongated nose and long tail (Ingle and Heany, 1992). According to locals, Island flying foxes (*Pteropus hypomelanus*) also occur in the area which is also noted to be hunted as food. Furthermore, CITES and DAO 2004-15 ranks the species in Appendix II and Vulnerable categories respectively.

Table 37 - List of observed volant and non-volant mammals.

Scientific Name	Common Name	IUCN Status[a]	CITES	DAO 2004-15	Distribution[b]	Observation	Captures
VOLANT MAMMALS							
HIPPOSIDERIDAE *Hipposideros diadema* (Geoffroy, 1813)	Diadem Horseshoe-bat	LC	-	-	R	Netted	5
PTEROPODIDAE *Cynopterus brachyotis* (Müller, 1838)	Short-nosed Fruit Bat	LC	-	-	R	Netted	1
PTEROPODIDAE *Rousettus amplexicaudatus* (É. Geoffroy Saint-Hilaire, 1810)	Common Rousette	LC	-	-	R	Netted	2
PTEROPODIIDAE *Pteropus cf. hypomelanus*	Island flying fox	LC	App II	Vul	R	ethno	-
NON-VOLANT MAMMALS							
MURIDAE *Rattus everetti*	Philippine forest mouse	LC	-	-	E	caught	2
MURIDAE *Rattus tanezumi*	Asian house rat	LC	-	-	R	seen	-

Scientific Name	Common Name	IUCN Status[a]	CITES	DAO 2004-15	Distribution[b]	Observation	Captures
CERCOPITHECIDAE *Macaca cf. fasicularis ssp. philippensis*	Philippine long-tailed macaque	NT	-	Thr	E	ethno	-
CERVIDAE *Cervus cf. marianus*	Philippine brown deer	Vul	-	Vul	E	ethno	-
VIVERRIDAE *Paradoxurus cf. hermaphroditus*	Common palm civet	LC	App III	-	R	Ethno and Seen	-

* [a]IUCN status: Vul=vulnerable, LC=least concern, NT=near-threatened, Thr=threatened

[b]Distribution: E=endemic, R=resident and M=migratory

Non-volant mammals were also observed and noted to occur in the area. A Philippine forest rat (*Rattus everetti*), a philippine endemic species with a distinct white band in its tail, was caught in traps in transects 1 and 4. Other endemic mammals noted from ethnobiological accounts are: Philippine long-tailed macaque (*Macaca cf. fasicularis*) and Philippine brown deer (*Cervus cf. marianus*) which were categorized as threatened and vulnerable species respectively according to IUCN and DAO 2004-15. According to locals, these species are commonly hunted for food in the area. There was also a probable sighting of an Common Palm civet (*Paradoxurus cf. hermaphroditus*) in the area particularly in transect 1. This species is listed as Appendix III in CITES in which trade have been officially regulated.

Mist Netting

A total of four (4) species of low flying/non-land bird species and three (3) species of volant mammals were caught in mist nets for a combined total of seven trap days and five trap nights. No mist nets were set in transect 5 for security purposes due to its proximity to households. As shown in *Figure 62*, among the species held are yellow-vented bulbul (*Pycnonotus goiavier*), white-throated kingfisher (*Halcyon gularis*), black-naped monarch (*Hypothymis azurea*) and mangrove blue flycatcher (*Cyornis rufigastra*). The conspicuous yellow vented bulbul, as its name suggests, has a distinct undertail coverts and was netted in transects 1 and 3 but was seen in all transects during the survey. The white throated kingfisher was caught near a river at the riparian forest in transect 2. The black-naped monarch which can tolerate fragmentation and forest clearings was held in the grassland area in transect 3. The mangrove blue flycatcher, netted in transect 4, is known to occur in disturbed forest and early secondary forest (Kennedy et al. 2000). Volant (bat) mammals were discussed in the previous section.

Netting success rate was computed by: number of species caught/number of combined trap days and trap nights. The resulting netting success rate during the survey is 116%. Based from this, there was a high over-all netting success rate based on a total of 14 species of birds and bats caught within seven trap days and five trap nights respectively. Details on the location and list species caught are shown in *Table 38*.

Table 38 - Location, trapping period and species caught during the mist netting survey.

Transect	Coordinates	Trap days	Trap nights	No. of species caught
1	15°39'16.60"N 119°57'57.76"E	1.5	1	2 birds (*P. goiavier)* 3 bats (*H. diadema* and *R. amplexicaudatus*)

Transect	Coordinates	Trap days	Trap nights	No. of species caught
2	15°40'1.98"N 119°57'51.58"E	2	1	1 bird (*H. gularis*) 3 bats (*H. diadema* and *C. brachyotis*)
3	15°35'47.97"N 120° 0'10.08"E	1.5	1	2 birds (*P. goiavier* and *H. azurea*) 1 bat (*H. diadema*)
4	15°37'43.86"N 119°58'32.21"E	2	2	1 bird (*C. rufigastra*) 1 bat (*H. diadema*)
Total		**7**	**5**	**14 (6 birds; 8 bats)**

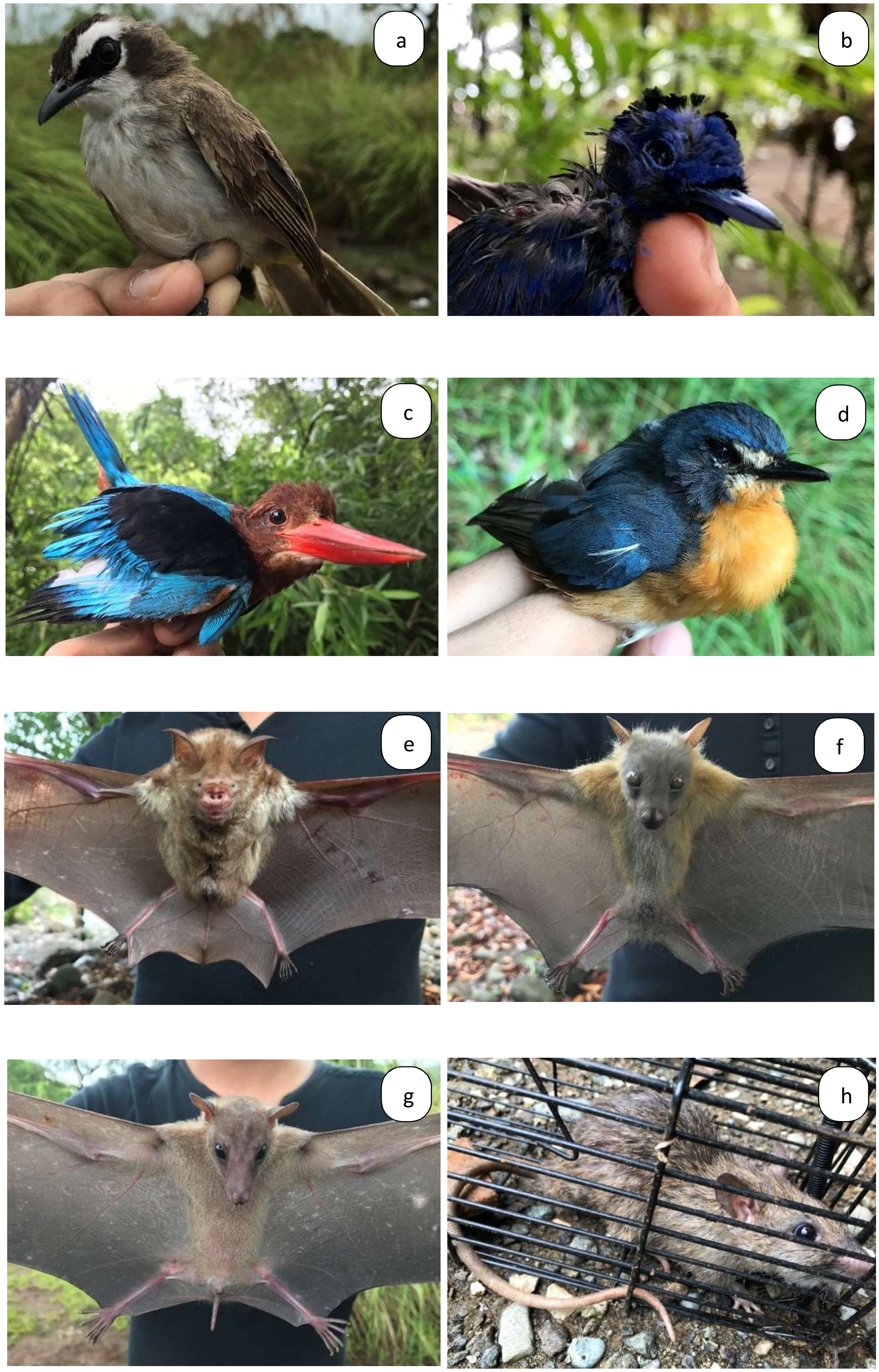


Figure 62 - Some of the caught bird and mammalian species in mist nets and traps during the conduct of the survey: a.) Yellow-vented Bulbul, b.) Black-naped Monarch c.) White-throated Kingfisher, d.) Mangrove Blue Flycatcher, e.) Diadem Horseshoe-bat, f.) Common Short-nosed Fruit bat, g.) Common rousette bat and h.)Philippine Forest rat

2.1.5.2.2.3 Amphibians and Reptiles

A total of eight species of amphibians and reptiles have been noted where four (4) are frogs, two (2) snakes, and two (2) lizards (*Table 39*). The species were listed from opportunistic sampling and ethnobiological accounts. Except for the Northern Philippine cobra (*Naja cf. philippinensis*), which is categorized as Near-threatened by IUCN and *P. reticulatus* as Appendix II by CITES, all other species were not listed by CITES and the DENR in DAO 2004-15. Furthermore, *N. philippinensis* is said to be endemic to the country and is threatened by habitat loss and hunting. According to Tanalgo (2017), other species which are noted to be hunted in the Philippines are: *P. reticulatus* and Common water monitor (*Varanus salvator*).

Anuran (frog) species belonging to four (4) families were also observed to occur in the area, such as the banded bullfrog (*Kaloula pulchra*). The said species is sensitive to changes in habitat weather conditions and temperatures within 27–29 °C (Encyclopedia of Life). *Rhinella marina* is 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 area.

Table 39 - List of observed amphibian and reptilian species.

Scientific Name	Common Name	IUCN Status[a]	CITES	DAO 2004-15	Distribution[b]	Observation
FROGS AND TOADS						
BUFONIDAE *Rhinella marina* (Linnaeus, 1758)	Cane toad	LC	-	-	Resident	Seen
MICROHYLIDAE *Kaloula pulchra* (Gray, 1831)	Banded bullfrog	LC	-	-	Resident	Heard
RHACOPHORIDAE *Polypedates leucomystax* (Gravenhorst, 1829)	Common tree frog	LC	-	-	Resident	Seen
CERATOBATRACHIDAE *Platymantis dorsalis* (Duméril, 1853)	Dumeril's Wrinkled Ground Frog	LC	-	-	Resident	Seen
SNAKES AND LIZARDS						

Scientific Name	Common Name	IUCN Status[a]	CITES	DAO 2004-15	Distribution[b]	Observation
ELAPIDAE *Naja cf. philippinensis* (Taylor, 1922)	Northern Philippine cobra	NT	-	-	Endemic	Ethno
PYTHONIDAE *Python reticulatus*	Reticulated python	LC	App II	-	Resident	Ethno
VARANIDAE *Varanus salvator* (Laurenti, 1768)	Common water monitor	LC	-	-	Resident	Ethno
SCINCIDAE *Lamprolepis smaragdina*	Emerald tree skink	LC	-		Resident	Seen

* [a]IUCN status: Vul=vulnerable, LC=least concern, NT=near-threatened
[b]Distribution: E=endemic, R=resident and M=migratory

2.1.5.2.3 Potential Impacts of the project on Terrestrial Fauna

Mining activities such as access road construction, exploration drilling, tailings and smelter emissions causes direct impacts such as: land clearance, water contamination and air and noise pollution. These impacts are easy to confirm and assess while the indirect impacts brought about by changes in the environment are not readily evident. Because of this, mining, despite its importance, is often questioned in favor of conserving biodiversity (IUCN and ICMM 2004).

Land clearance from mining results to the destruction, fragmentation and loss of habitat which poses great threat to wildlife species and causes imbalance in nature (Gajera et al., 2013). This can result to the disturbance, displacement and removal of wildlife species within the area at peak during the construction and operations phase of the project. Among the species that are likely to be affected are those which are already threatened as listed by IUCN, CITES and DENR in DAO 2004-15. Moreover, endemic species which have a limited distribution may be affected as well.
Studies have also shown that among birds, changes in edge and habitat area affects bird diversity, also, area sensitive avifauna and small patches of remnant native forest only support a small number of forest birds (Loyn et al., 2010). Likely to be affected are specialist species which have a limited capacity in terms of feeding guild. Loss of their habitat i.e. food source will result to lesser structural support which may not be able to support a variety of birds and other wildlife species' niche. A study by Hernandez (2008) revealed that deforestation and more importantly, land-cover change decreases the possible spatial distribution of endemic bird species because of reduced habitat area and prevalence of competitors and parasites.

Studies show that bird counts and the density of birds declined significantly in air and noise polluted forests compared to non-polluted forest sites. It was also cited that air pollution causes physiological and behavioral disturbance among bird species. Noise pollution can cause physical damage to ears, stress responses, flight or flushing responses, changes in foraging, and other behavioral reactions of birds in laboratory conditions (Ortega 2012). In areas of high air pollution, birds have higher breathing rate and are more exposed to open air where particles can penetrate deep into the lungs of birds (Qin 2015).

2.1.5.2.4 Mitigation Measures for the Potential Impacts

Regular monitoring through annual or semi-annual assessment (wet and dry season) of wildlife species should be done as a mitigation measure against the identified potential impacts. Birds may be prioritized to assess since they are said to be good indicators of habitat quality. They respond to habitat functions and there are species which are sensitive to habitat conditions (BirdLife International). Among the parameters to be monitored should be: 1.) *diversity indices* *(i.e. species richness, evenness and dominance*); 2.) *Abundance and richness of endemic and threatened species listed in IUCN, CITES and DENR in DAO 2004-15* and 3.) *Species count/population studies of keystone species which other species depend on for biological necessities*. These keystone species include: seed dispersers (e.g. fruit bats and fruit doves) and top predators (raptorial birds, and snakes).

Buffer zones should also be clearly designated as no-take zones to enhance the conservation value of the area amidst mining and habitat fragmentation (Sayer, 1991). This provides assurance for the refuge of displaced species as well structural support for various niches of wildlife species. Employment of progressive rehabilitation of local species can also be done. These rehabilitated areas can serve as critical corridors for birds and other wildlife species travelling across the fragmented habitat in the area. It also suggested rehabilitating first the mined-out parcel of land before mining another parcel to minimize fragmentation as much as possible.

It is further recommended to construct a temporary shelter for accidentally captured species including those that pose threat to workers and the local community. It is also prescribed to have an on call veterinarian to attend to the wildlife species in the area.

Lastly, mining improves accessibility to certain areas which may be taken for granted by illegal hunter/poachers. With this, increased security in the area should be done to apprehend violators. Moreover, IEC materials about the importance of wildlife conservation may be distributed to increase awareness and knowledge of the local community.

2.2 Water

2.2.1 Hydrology/Hydrogeology

2.2.1.1 Surface Water Bodies and Drainage Areas

2.2.1.1.1 Watershed Delineation – Sta. Cruz Area (EISWestChinaMin, 2016)

In the Perlas area, a small tributary known as Patogo river that flows along northeast will be tapped as alternate water source. This creek will flow to Nayom River as the main downstream. Figure 2-49 shows the hyrdrologic map within the Perlas site. There are three (3) significant river systems present, namely, Nayom, Sta. Cruz and Cabaluan Rivers. These generally flow westerly and discharge their loads to the South China Sea/West Philippine Sea. Among these three, Nayom River has the biggest discharge. The Infanta Dam is used to divert and control Nayom River for irrigation purposes. A 15-year record taken from a gauging station upstream of the dam yielded an average flow of 415 m3/s. On the other hand, Sta. Cruz and Cabaluan Rivers were observed to have lesser runoff compared to Nayom River. These rivers can be a potential source for irrigation water.

The main water system of Nayom River is about 47.1 kilometers. The two main tributaries of this river that contribute more water are the San Felipe and Babuyan River Pangasinan. Its headwater comes from Mount Mangatarem in Babuyan, Mount Maliang and Mount Nangradian in barangay Pita, Infanta, Pangasinan and Zambales mountains in Babuyan, Sta. Cruz, Zambales. It passes through barangay Pita, Nangalisan and Doliman, Infanta, Pangasinan barangay Guinabon, Canaynayan, Pamonoran and Gama in Sta. Cruz Zambales It exits in Dasol Bay in Infanta, Pangasinan.

2.2.1.1.2 Watershed Delineation – Proposed Project Area

The proposed additional total project area (1,730.56 hectares) consists of three (3) parcels of MPSA No. 316-2010-III, Amended I namely Parcel II, Parcel VII and Parcel VIII. Parcel II (area=1,483.35 ha) comprises about 85.7% of the total area followed by Parcel VII (area=164.79 ha) and Parcel VIII (area=82.42 ha) covering 9.5% and 4.8% of the total area, respectively. Based on the NAMRIA topographic map, surface water bodies that may be impacted by the Project include Agnacon River, San Vicente River, Lauis River, and the coastal area of Candelaria where outlets of these rivers are located (*Figure 63*). Lauis River is one of the Principal Rivers of Central Luzon Water Resources Region with a drainage area covering about 406 km^2 or 40,600 ha. Drainage areas of Agnacon River and San Vicente River are 7,541 ha and 3,595 ha, respectively. Determining the characteristics of watershed (i.e. area, topography, land use, etc.) and the area of the project relative to the watersheds covering the project area would be helpful in assessing the project impacts on hydrology and water quality. The quality and quantity of water passing through a certain reference point or outlet of a watershed is highly dependent on the watershed characteristics and on the activities within that watershed.

In terms of subwatersheds, the Agnacon River can be subdivided into three subwatersheds – Pader (drainage area (DA) = 872 ha), Duplac River (DA=1,353 ha) and Balin-Buaya River (DA=3,697 ha) – and a floodplain area (1,619 ha) where Uacon Swamp and Malabon River can be found. On the other hand, the San Vicente River can be subdivided into two tributaries, the Sto. Niño Cave River 1 at the north (DA=1,015 ha) and Sto. Niño Cave River 2 at the south (DA=952 ha). The remaining drainage area of the San Vicente River is also floodplain area of about 1,628 ha. Only a small portion of the project area, 61 ha of Parcel VIII, is within the Lauis Watershed. Subwatershed map is presented in *Figure 64*.

Located north of the Parcel II and Parcel VIII, Parcel VII is drained mainly by the two tributaries of Agnacon River. Runoff from the southern portion of Parcel VII, with an area of about 54 ha drains into the Duplac River which is connected to the Uacon Swamp then to the Agnacon River. The northern portion of Parcel VII (area=111 ha) on the other hand is drained by Pader River which is connected to the Agnacon River downstream of the Uacon Swamp.

Two main rivers drain Parcel II. These are Agnacon River at the north and San Vicente River at the south. Both rivers drain into the coastal area of Candelaria located west of the project site. Balin-Buaya River and Duplac River, both tributaries of Agnacon River, traverses the northern portion of Parcel II. About 48 ha and 653 ha of Parcel II is within the Duplac subwatershed and Balin-Buaya subwatershed, respectively. From the project site going downstream, Balin-Buaya River is connected to the Malabon River which is connected to the Uacon Swamp and eventually to the main Agnacon.

River. The southern portion of Parcel II (784 ha) is within the Sto. Niño Cave River subwatershed, a tributary of San Vicente River.

The southernmost and smallest parcel, Parcel VIII, is mainly drained by North Lauis River, one of the principal rivers in Central Luzon Water Resources Region. About 61 ha of Parcel VIII is within the Lauis watershed. The remaining area (about 21 ha) of Parcel VIII is within the Sto. Niño subwatershed.

A map showing the partitioning of the Project area in terms of the different subwatersheds covering the Project is presented in *Figure 65*while *Table 40* summarizes the project area distribution relative to the drainage areas of the rivers within or draining the project site.

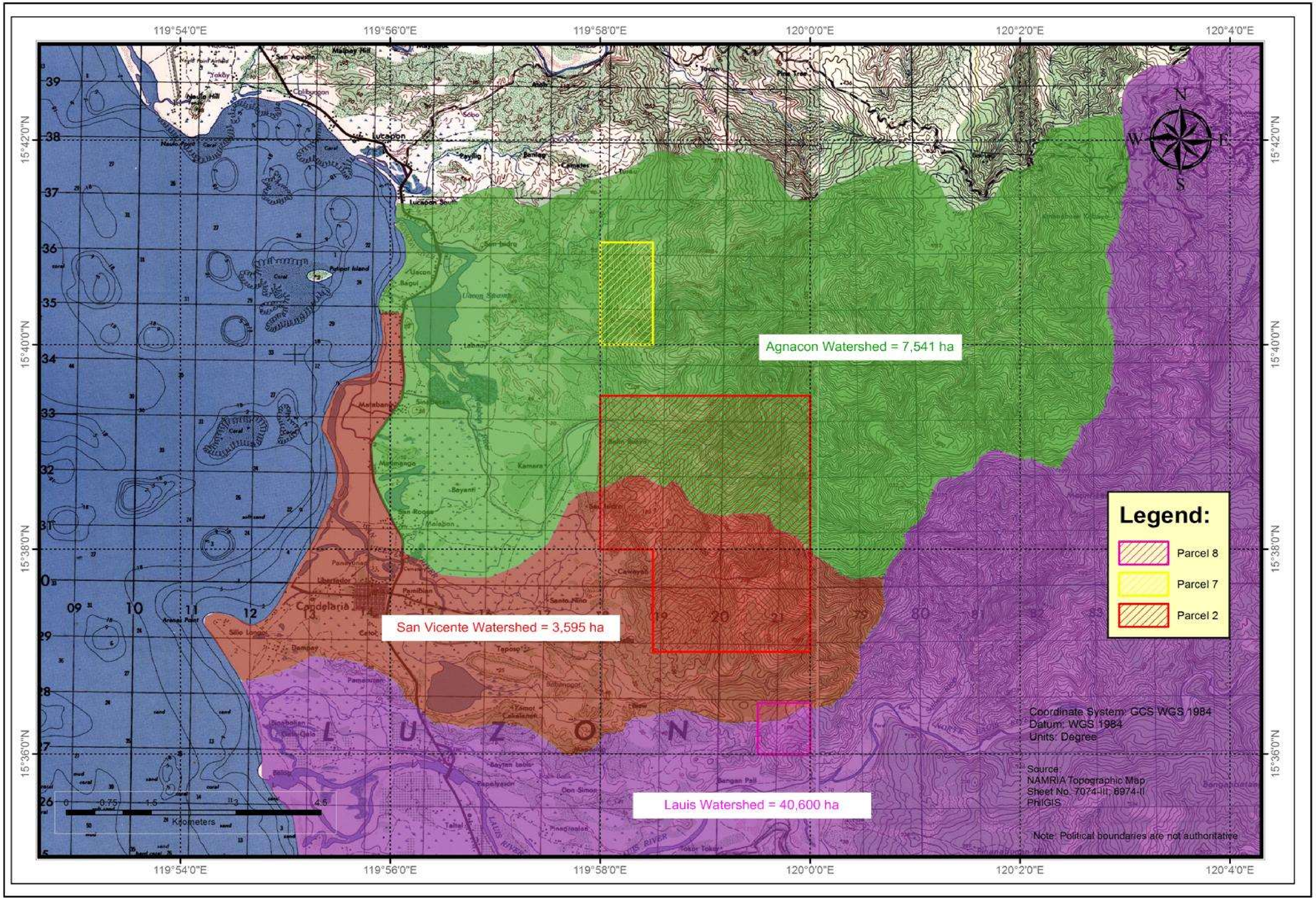


Figure 63 - Drainage map showing the watershed divide of the three main rivers draining the Project area

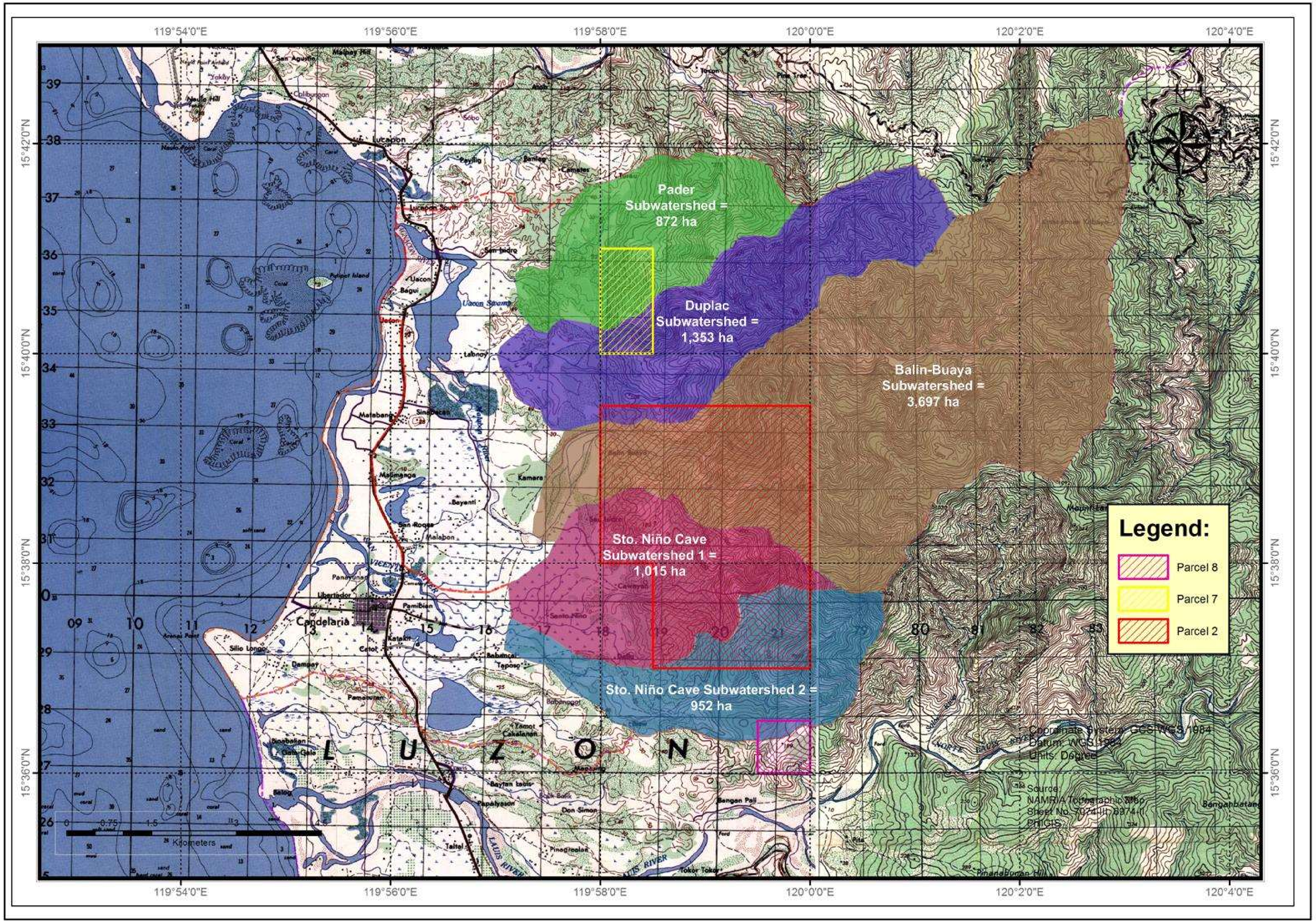


Figure 64 - Subwatershed Map

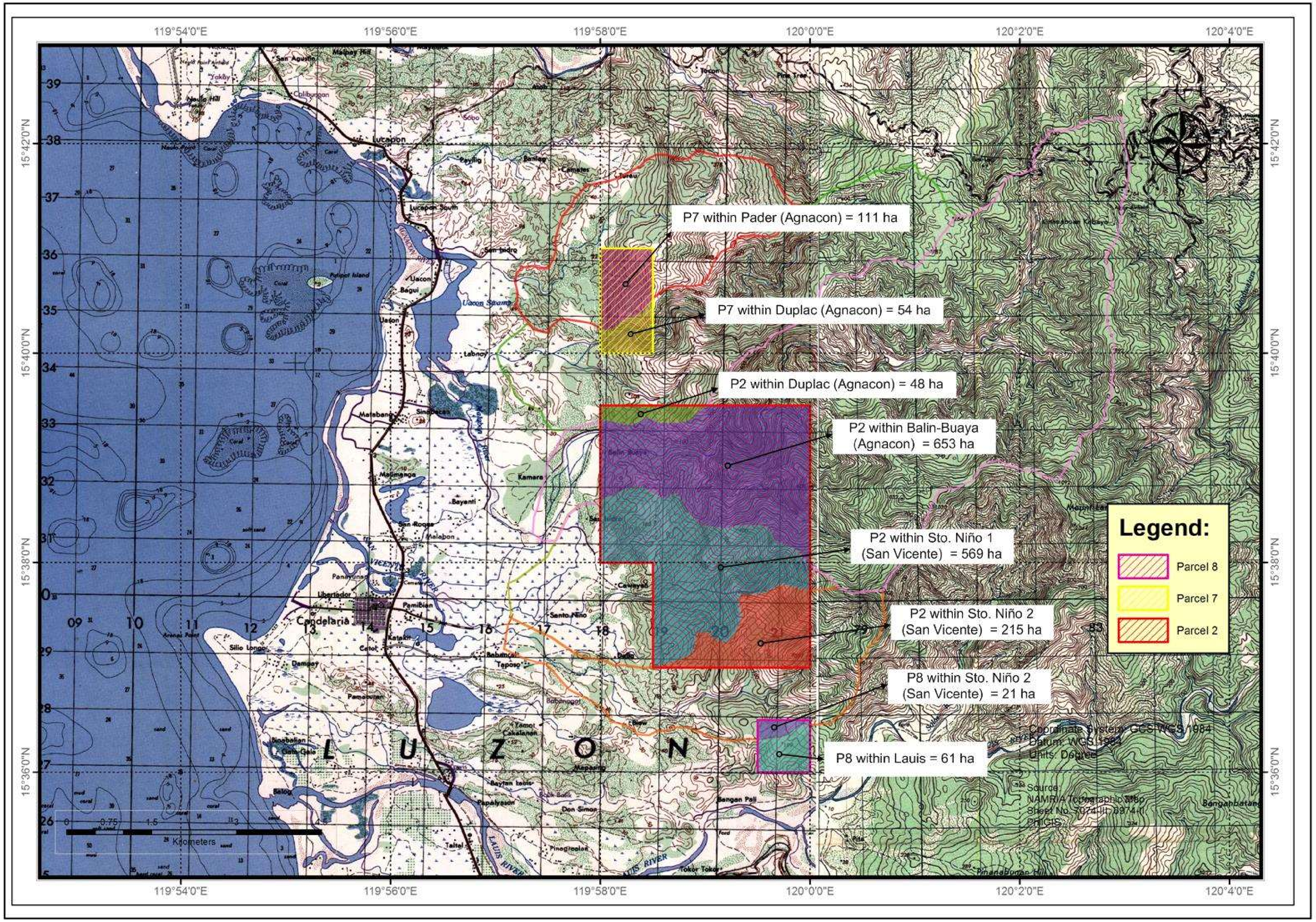


Figure 65 - Map showing the partitioning of the Project area in terms of the different subwatersheds covering the Project

Table 40 - Summary of the project area distribution relative to the drainage areas of the rivers within or draining the project site

Parcel	Area (ha)		Project area within the watershed							
		Watershed	Agnacon (DA=7541 ha)				San Vicente (DA=3595 ha)			Lauis (DA=40,600 ha)
		Subwatershed	Pader (DA=872 ha)	Duplac (DA=1353 ha)	Balin-Buaya (DA=3697 ha)	Floodplain (DA=1619 ha)	Sto. Niño 1 (DA=1015 ha)	Sto. Niño 2 (DA=952 ha)	Floodplain (DA=1628 ha)	
VII	165	Project area within the watershed (ha)	111	54	0	0	0	0	0	0
		% of Parcel Area	67%	33%						
				100%						
		% of the Subwatershed	13%	4%						
		% of Total Project Area		10%						
		% of the Watershed Area		2%						
		REMARKS	● 67% of Parcel VII is within Pader Subwatershed comprising 13% of Pader total drainage area ● The remaining 33% of Parcel VII is within Duplac Subwatershed comprising 4% of the Duplac total drainage area ● Parcel VII comprise about 10% of the total project area. It is entirely within the Agnacon Watershed. ● The entire Parcel VII is within the Agnacon Watershed. It covers 2% of the Agnacon drainage area.							
II	1,484	Project area within the watershed (ha)	0	48	653	0	569	215	0	0
		% of Parcel Area		3%	44%		38%	14%		
					47%			53%		
		% of the Subwatershed		4%	18%		56%	23%		
		% of Total Project Area			40%			45%		
		% of the Watershed Area			9%			22%		
		REMARKS	● 3% of Parcel II is within Duplac Subwatershed comprising 4% of the Duplac total drainage area ● 44% of Parcel II is within Balin-Buaya Subwatershed comprising 18% of the Balin-Buaya total drainage area. ● 38% of Parcel II is within Sto. Niño 1 Subwatershed comprising 56% of the Sto. Niño 1 total drainage area. ● The remaining 14% of Parcel II is within Sto. Niño 2 Subwatershed comprising 23% of the Sto. Niño 2 total drainage area. ● Parcel II comprises about 85% of the total project area (40% within the Agnacon Watershed and 45% within San Vicente Watershed) ● About 47% of Parcel II is within Agnacon Watershed comprising 9% of the total Agnacon drainage area; the remaining 53% is within San Vicente Watershed covering 22% of the total San Vicente drainage area.							
VIII	82	Project area within the watershed (ha)	0	0	0	0	0	21	0	61
		% of Parcel Area						26%		74%
		% of the Subwatershed						2%		0.2%
		% of Total Project Area						1%		4%
		% of the Watershed Area						1%		0.2%
		REMARKS	● 26% of Parcel VIII is within Sto. Niño 2 Subwatershed comprising 2% of the total Sto. Niño 2 total drainage area ● The remaining 74% of Parcel VIII is within Lauis Watershed comprising 0.2% of the total Lauis drainage area. ● Parcel VIII comprises about 5% of the total project area (1% within the San Vicente Watershed and 4% within Lauis watershed)							
OVERALL REMARKS			● 50% of the project area is withing the Agnacon Watershed; 46% of the project area is within the San VicenteWatershed; and the remaining 4% of the project area is within Lauis Watershed.							

2.2.1.1.3 Flood Susceptibility and Change in Drainage Morphology

The project area is largely characterized with well developed drainage systems following a dendritic pattern. Runoff generally flows from the mountainous region east of the project site to the coastal plains bordering the project area at the western side. Several creeks/rivers cut across the project area including Duplac River in Parcel VII, Balin-Buaya and Sto. Niño Rivers in Parcel II and an unnamed creek connecting to Lauis River in Parcel VIII.

The susceptibility of the project to flooding was determined by overlaying the project boundaries on the Flood Susceptibility Map of the Mines and Geosciences Bureau (MGB). As shown in *Figure 66*, there are areas within the project boundaries that highly susceptible to flooding particularly the sections traversed by the rivers or creeks. Flooding in these areas would most probably be in the form of overflow or water flowing over the banks of a river or stream. Given the said information, precautions and careful design of the drainage system for the project must be undertaken to prevent possible flooding that may eventually result in accelerated erosion within the project area. Moreover, the mining method for the project is surface mining method specifically contour or strip mining to extract the nickel ores. Prior to mining, site preparation would involve clearing of vegetation, overburden removal, excavation and other earthmoving activities that will inevitably change the drainage patterns within the project area. The change in drainage patterns may lead to localized flooding and also increased surface runoff within the project area due to land clearing. Runoff coming from the project site will eventually drain to the floodplains bordering the western section of the project site. These floodplain areas are already highly susceptible to flooding as shown in the flood susceptibility map of MGB. Further changes in the drainage morphology within the watershed caused by clearing of vegetation and excavation works during the construction and operation phase of the project may contribute to a sudden rise of floodwaters or increased river peak flows. The exposed sections of the mine area including the stockyard, overburden or waste dumps and stockpile areas are also prone to washing or erosion that may cause sediment deposition and decrease in stream water depths downstream, including the coastal areas of Candelaria.

Considering the climate change projections in Zambales province, seasonal rainfall is estimated to increase for the period December to February (34.2%) and June to August (13.3%) in 2020. In 2050, it is projected that the months of June to August and September to November will experience a 31.4% and 5.6% increase in rainfall, respectively. As shown in *Figure 67*, the increase in rainfall may have a significant effect during the months of June to August in terms of flooding since the observed baseline during this period is already relatively high (1,793.9 mm). Based on the existing resource/reserve, the project will have a mine life of 14 years which can be extended upon discovery of additional resource/reserve during the continuing exploration activities. This means that the projected increase in seasonal rainfall will be experienced during project implementation.
The abovementioned project impacts shall be mitigated through installation of an effective drainage system connected to adequately-sized settling ponds (in series) and other erosion control facilities.

Diversion canals shall be installed to route the surface runoff, coming from the mountainous area east of the project site, from reaching the mine area thereby preventing erosion and localized flooding within the project site. Drainage canals shall be installed within the project site to convey silted runoff to the settling ponds thereby preventing transport and deposition of eroded materials to the surface water bodies downstream. Construction and mine development shall follow the set easement from the natural drainage systems (rivers and creeks) within the project area. In case of river diversion, engineering measures shall be implemented to ensure that the relocated channels are stable. Progressive rehabilitation of the mine site shall also be implemented to minimize the effect of land clearing on the possible upsurge in peak runoff that may contribute to the possible flooding in the floodplain areas bordering the project site. A climate change adaptation (CCA) and disaster risk reduction (DRR) program shall be developed for the project. The development of a Nursery and rehabilitation proram shall be part of the CCA. An Emergency Response Team shall also be created for the project and shall act as first responders in case of hydrologic hazards such as flooding.

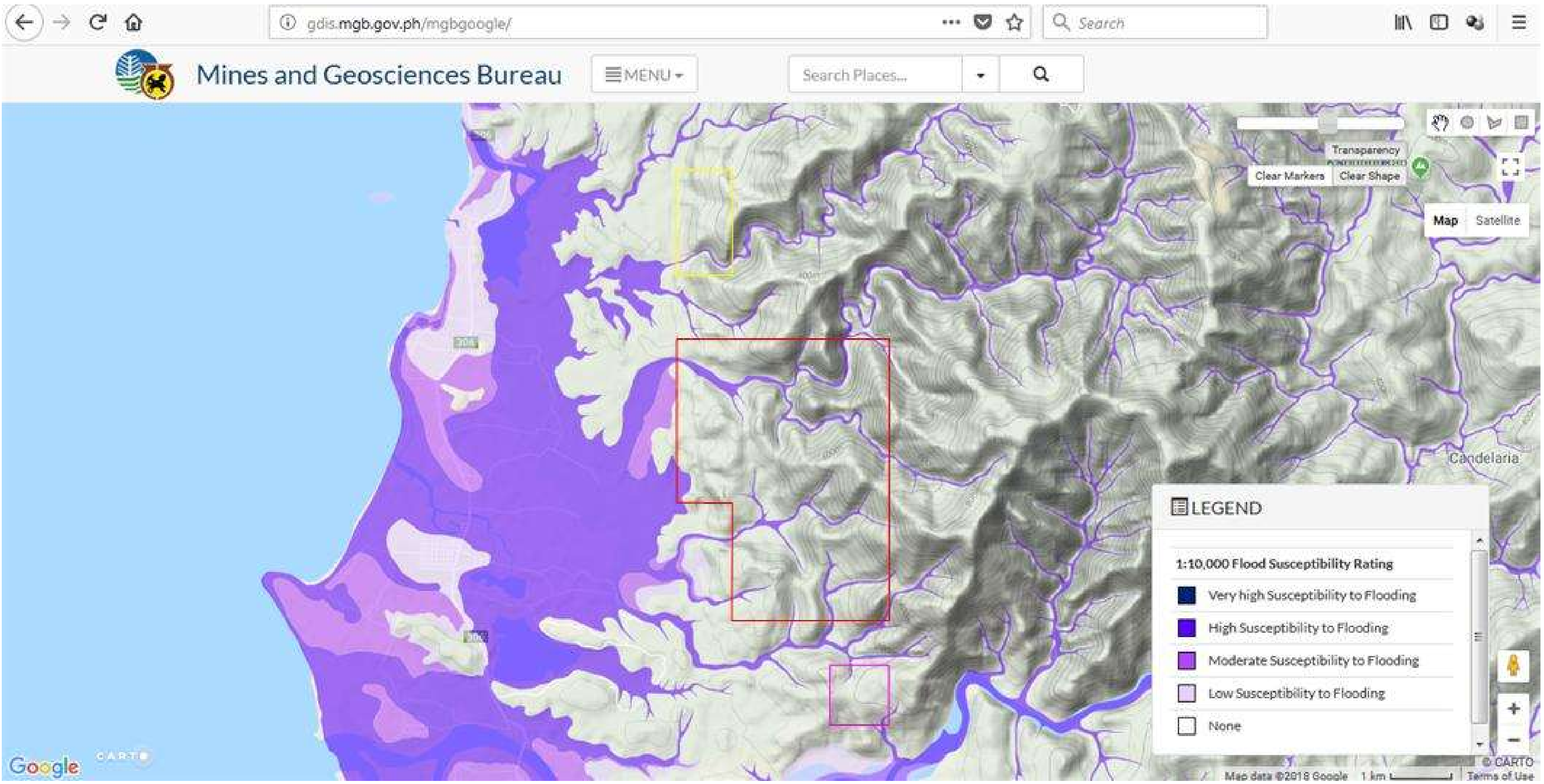


Figure 66 - Screenshot of the MGB Flood Susceptibility Rating Map showing the project area

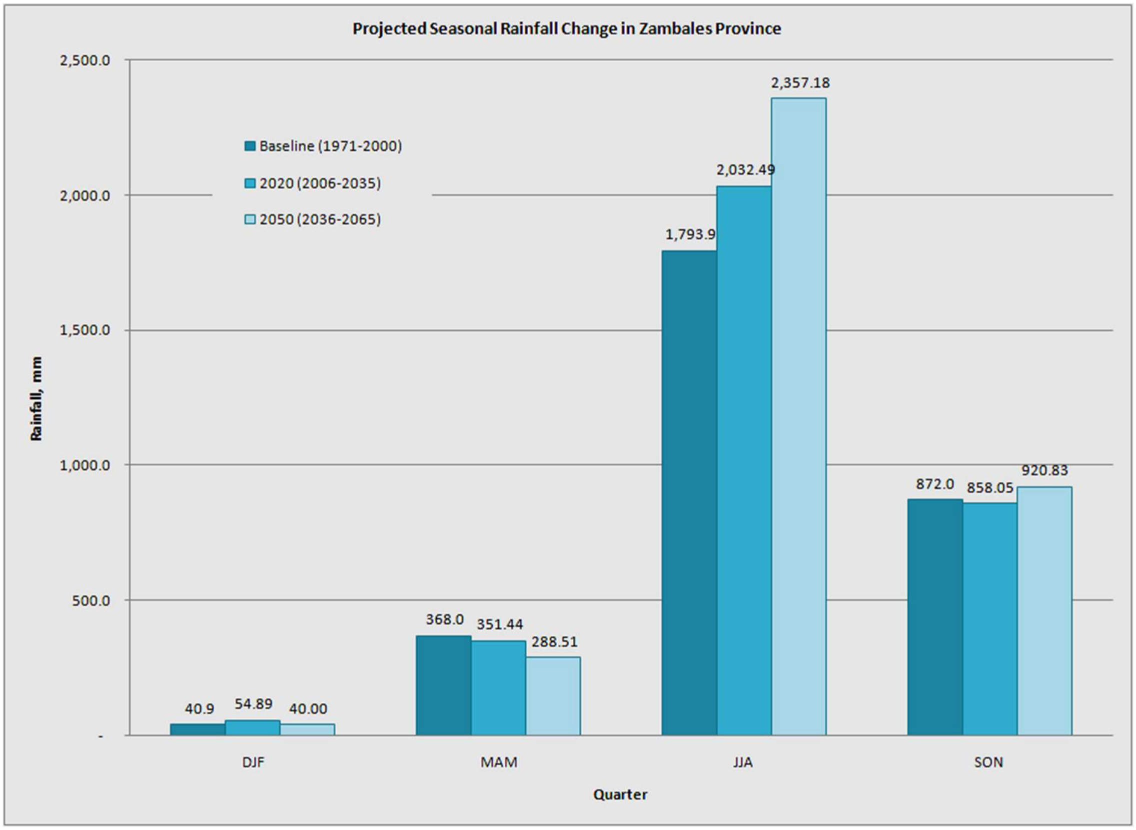


Figure 67 - Projected seasonal rainfall change in 2020 and 2050 in Zambales Province

2.2.1.2 Groundwater Resource

Groundwater resource in Zambales Province can be categorized into shallow well areas, deep well areas and difficult areas. The most promising source of groundwater in the province, according to the Soils/Land Resources Evaluation Report of the Bureau of Soils and Water Management (1988), are the shallow well areas located in the broad alluvial, coastal plain and river valleys. These areas are composed of recent formations with slopes ranging from 0-3%. Shallow well areas usually have depths not greater than 20 meters and are generally within 6 meters below ground surface (mbgs). Most of these areas are located at elevations within 50 meters above sea level (masl). Deep well areas on the other hand can be found on regions with slopes greater 10 percent and at elevations greater than 50 masl. Static water level of deep wells usually exceeds 6 meters below ground surface with well depths usually greater than 20 meters. Unlike the shallow well areas and deep well areas, difficult areas have varying slopes, elevation and water depth. About 25 percent of such areas may yield non-productive boreholes. Springs are typically found in these difficult areas. (BSWM, 1988)

As shown in the Groundwater Availability Map (*Figure 68*), the project area belongs to a region with underlying local and less productive aquifer. As per MGB description of aquifer types, local and less productive aquifers are intergranular and variably permeable aquifers with yields mostly 2-20 liters per second.

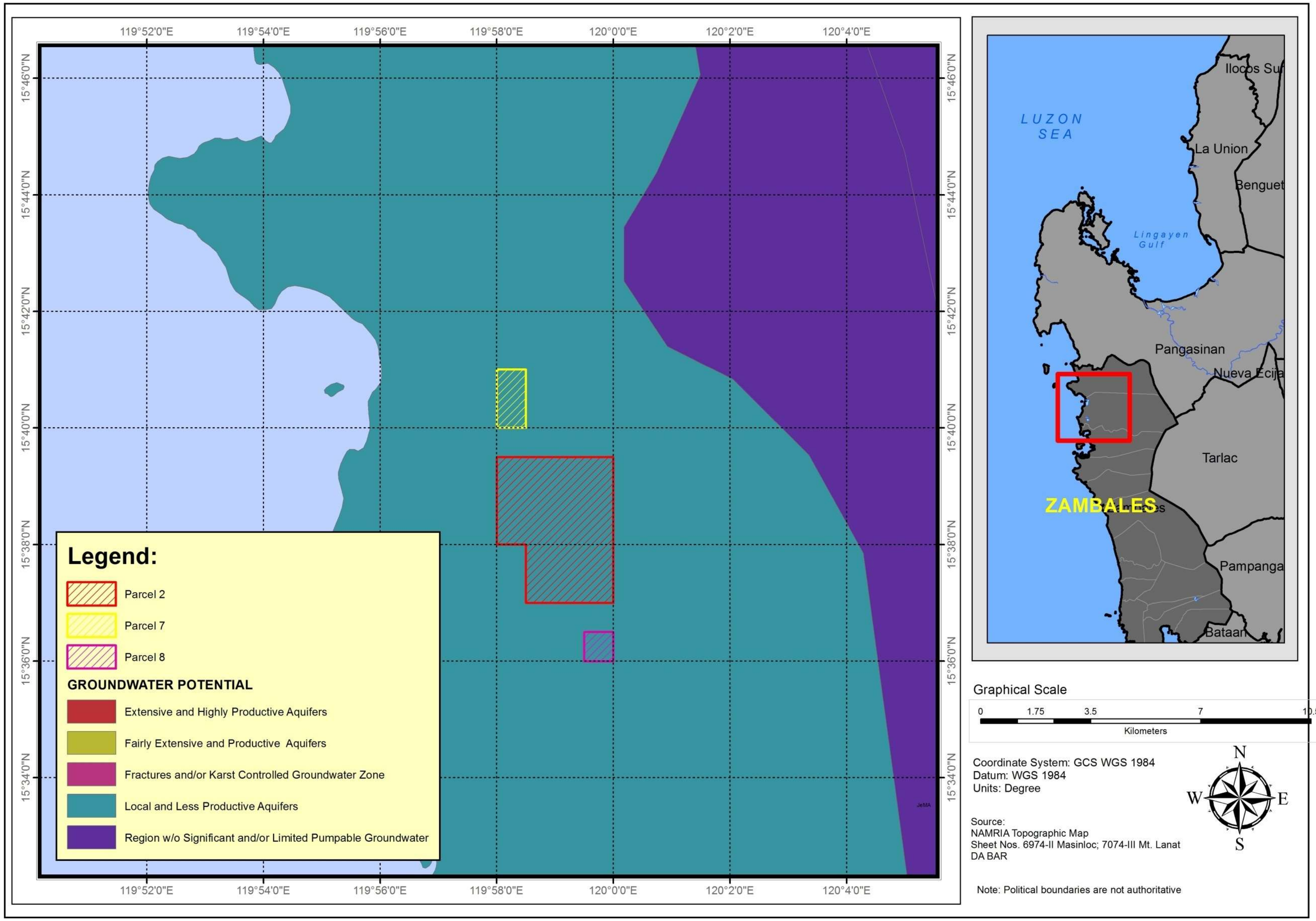


Figure 68 - Groundwater Potential Map

2.2.1.2.1 Available Sources of Groundwater – Sta. Cruz Area (EISWestChinaMin, 2016)

Local residents rely on few artesian wells in Brgy. Canaynayan for their domestic water needs. The sources aquifer of these artesian wells maybe hydrologically connected to the surface flow of Sta. Cruz and Nayom Rivers. Groundwater is stored at QAl hydrologic unit. The yield of these wells presently supply the potable water needs of the residents of Brgy. Canaynayan and some residents of the nearby barangays. But for future demands, discharge of these wells may turn out to be insufficient for the future needs of additional population.

At the Perlas MPSA, the ultramafic bedrock is classified by the NWRB as a difficult area where water bearing horizons can only exist along fractures, faults and other geological discontinuities. Springs issuing out of the geologic discontinuities can be tapped as source of domestic water supply. For industrial water sources, the discharge of the perennial creeks can be utilized such as the water from Patogo River. According to the National Water Resources Council (NWRC), the project site is located within the difficult area for groundwater accessibility. Also, the area is underlain by ultramafic rocks which are generally impermeable. These rocks allow the storage and movement of groundwater through faults and fractures only. However, these fractures are usually tight and are slightly open only in the weathered zones. Hence, there is no possibility of obtaining groundwater through drilling, and open cuts will probably not intercept any aquifer in the area.

2.2.1.2.2 Water Resource Use

The Project will be needing water for industrial and domestic use. Several options are currently being considered for the water source, these are: surface water from the nearest river or creek, groundwater via deep well(s), rainwater, and possibly water delivery trucks. A water storage tank will be constructed within the Ferro-nickel Processing Complex.

Water will mainly be used for road watering, washing, processing, irrigation and for domestic use. Water from the settling ponds is also being considered for reuse. A rainwater collection system is also being considered to minimize surface and groundwater extraction. A Hydrogeological Study shall be conducted to identify potential water sources for the Project.
Necessary permits shall be acquired from NWRB prior to any surface or groundwater extraction activities.

2.2.2 Water Quality

Discussed in this section are the results of water quality baseline study for the Environmental Impact Assessment of the proposed Zambales Ferro-Nickel Plant and Mining Expansion Project.

2.2.2.1 Methodology

Water sampling was done to represent the water quality during the wet and dry season. Zambales Province falls under Type I Climate with two pronounced seasons, dry from November to April and wet during the rest of the year. Annual rainfall normal value (1981-2010) at Iba, Zambales PAGASA Synoptic Station is 3,450.7 mm. Monthly rainfall normal values during the dry season range from 4.1 mm to 62.3 mm. During the wet season, monthly rainfall normal values range from 234.2 mm to 897.7 mm.

Water sampling for the dry season was conducted on April 27-28, 2018 while sampling for the wet season was conducted on June 11-12, 2018. Water sampling stations were initially identified using a map with the project area boundaries and watershed boundaries superimposed on a NAMRIA topographic map of the area (Sheet Nos. 6974-II Masinloc and 7074-III Mt. Lanat).

A total of eighteen (17) water quality sampling stations were established for this EIA study – eleven (10) freshwater stations, three (3) groundwater stations and four (4) marine water stations (see *Table 41* and *Figure 69*). Parameters analyzed in-situ, using a portable water tester, were: pH, dissolved oxygen (DO), total dissolved solids (TDS), temperature and conductivity. Grab samples were also collected and sent to the laboratory for the analysis of parameters: arsenic (As), cadmium (Cd), lead (Pb), manganese (Mn), nickel (Ni), Mercury (Hg), Total and Fecal Coliforms, chemical oxygen demand (COD), total suspended solids (TSS), oil and grease (O&G), nitrate-N (NO_3-N) and sulfate (SO_4).

Table 41 - Description of Water Quality Sampling Stations

Station ID	Location	Geographic coordinates
Freshwater		
P2-C	Balin Buaya River, inside Parcel 2	15°39’02.0” N 119°58’34.9” E
P2-D	Balin Buaya River downstream, at the western boundary of Parcel 2	15°39’14.8” N 119°58’02.4” E
P2-E	Sto. Niño Cave River 1 (north tributary), within Parcel 2	15°37’46.9” N 119°58’41.6” E
P2-F	Sto. Niño Cave River 1 (north tributary) downstream, draining Parcel 2	15°37’40.8” N 119°58’25.7” E

Station ID	Location	Geographic coordinates
P2-G	Sto. Niño Cave River 2 (south tributary), draining Parcel 2	15°36'56.0" N 119°58'05.8" E
P7-A	Duplac River within Parcel 7	15°40'07.2" N 119°58'05.8" E
P7-B	Duplac River downstream of Parcel 7	15°40'06.3" N 119°57'55.5" E
P7-C	Pader River downstream of Parcel 7	15°41'00.7" N 119°57'50.1" E
P8-A	North Lauis River, main, upstream of the tributary draining Parcel 8	15°35'48.9" N 120°00'16.3" E
P8-C	North Lauis River, main, downstream of confluence of tributary draining Parcel 8	15°35'37.4" N 119°59'31.5" E
Groundwater		
GW1	Brgy. Taposo, approximately 500 m west of Parcel 2	15°37'14.6" N 119°58'13.6" E
GW2	Brgy. Pinagrealan, approximately 500 m south of Parcel 8	15°35'42.9" N 119°59'27.5" E
GW3	Brgy. Sinabacan, approximately 2 km west of Parcel 2 (outside)	15°39'06.8" N 119°56'46.9" E
Marine Water		
MW1	Near Potipot Island and Agnacon River outlet	15°41'13.4" N 119°55'46.9" E
MW2	Near Candelaria Marine Fish Sanctuary	15°39'45.3" N 119°55'18.1" E
MW3	Near San Vicente River outlet/mouth	15°38'28.9" N 119°54'59.6" E
MW4	Near North Lauis River/Masinloc Power Plant	15°35'39.8" N

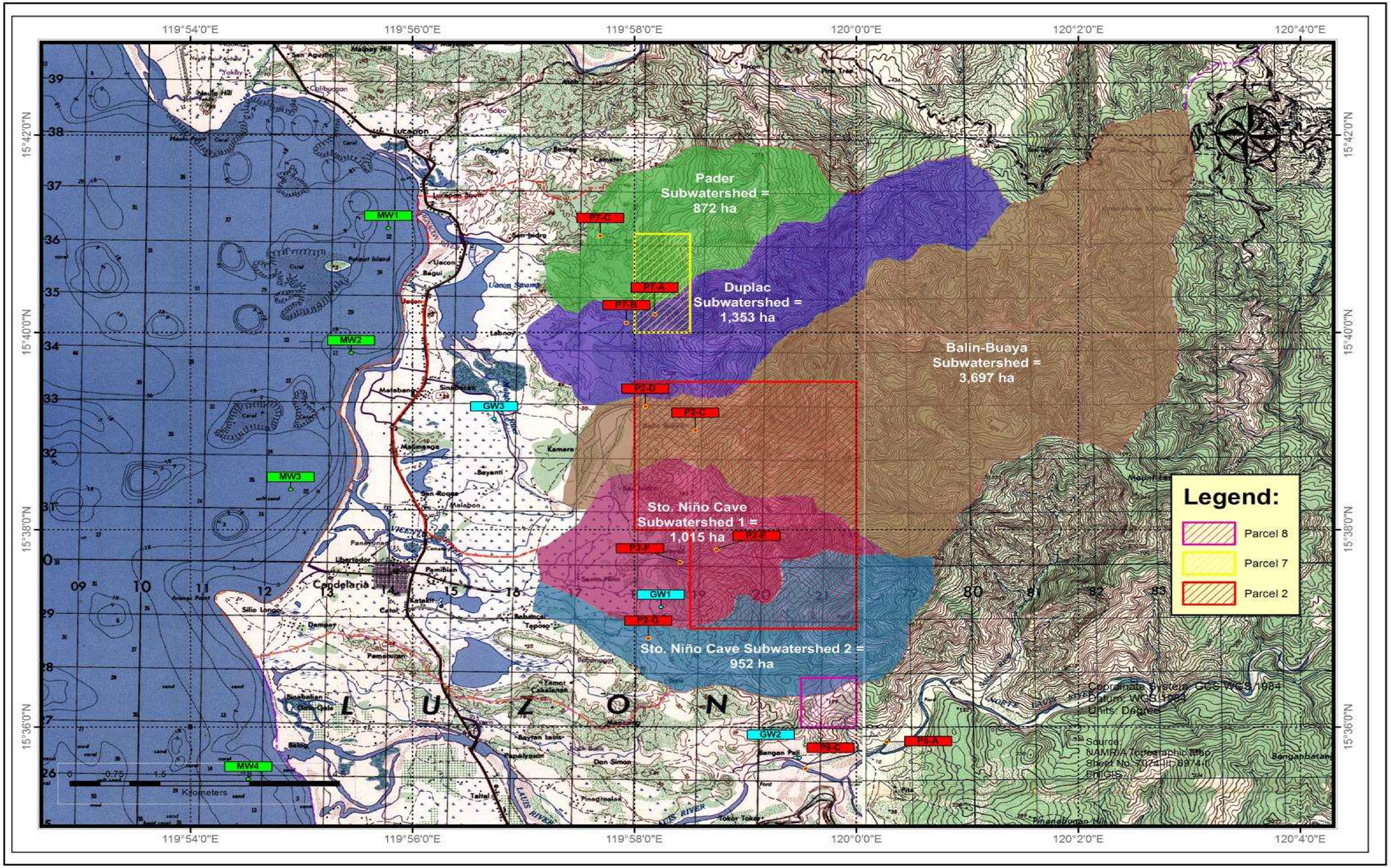
Station ID	Location	Geographic coordinates
		119°54'39.4" E

Results of water quality analysis were compared to the Class C[2] guidelines/standards set in the DENR Administrative Order 08 of 2016 (DAO 2016-08) – *Water Quality Guidelines and General Effluent Standards of 2016* to assess the current status of surface water quality in Parcel 2 and Parcel 7 surface water quality stations . DAO 2016-08 Class C guidelines/standards was used based on the current or intended beneficial use of freshwater in the area (for agriculture, irrigation, and livestock watering) particularly in the floodplain area where rice fields/farmlands are located. Lawis/Lauis River, a principal river, is classified by the EMB DENR under Class B[3] thus results of Parcel 8 surface water quality monitoring were compared to Class B guideline values.

Groundwater samples were collected from selected shallow tube wells used for domestic use. Results of groundwater assessment were compared to Class A water quality guidelines of DAO 2016-08.

Results for the marine water quality assessment were compared to Class SC[4] guidelines of DAO 2016-08. It should be noted that MW2 is located near the Candelaria Marine Fish Sanctuary while MW4 is located north of the Masinloc Oyon Bay Marine Reserve. Both stations, however, are outside the jurisdictions of the said marine sanctuary and marine reserve.

[2] DAO 2016-08 Class C – For agriculture, irrigation, and livestock watering
[3] https://water.emb.gov.ph/wp-content/uploads/2016/07/Classified-WB-2016.pdf
[4] DAO 2016-08 Class SC – For propagation and growth of fish and other aquatic resources and intended for commercial and sustenance fishing; For boating, fishing, or similar activities; Marshy and/or mangrove areas declared as fish and wildlife sanctuaries.


Pader
Subwatershed =
872 ha
Duplac
Subwatershed =
1,353 ha
Balin-Buaya
Subwatershed =
3,697 ha
Sto. Niño Cave
Subwatershed 1 =
1,015 ha
Sto. Niño Cave Subwatershed 2 =
952 ha
Legend:
Parcel 8
Parcel 7
Parcel 2
MW1
MW2
MW3
MW4
GW1
GW2
GW3
P7-C
P7-A
P7-B
P2-D
P2-C
P2-E
P2-F
P2-G
P8-C
P8-A
L U Z O N
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
119°54'0"E
119°56'0"E
119°58'0"E
120°0'0"E
120°2'0"E
120°4'0"E
15°42'0"N
15°40'0"N
15°38'0"N
15°36'0"N
Kilometers

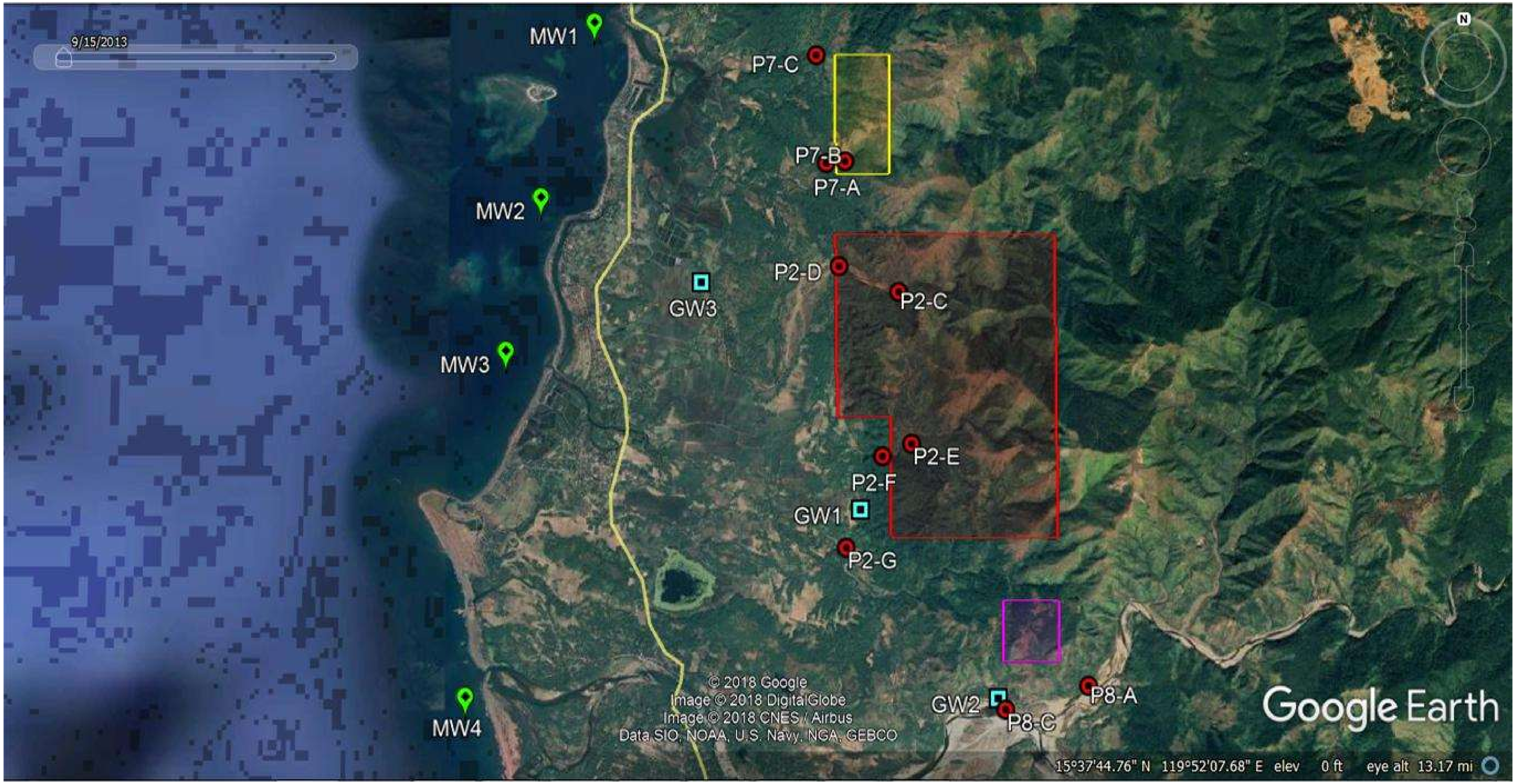


Figure 69 - Water Quality Sampling Map

Plate 1 - Surface Water Station P2-C, dry season

Plate 2 - Surface Water Station P2-D, dry season

Plate 3 - Surface Water Station P2-E, dry season

Plate 4 Surface Water Station P2-F, dry season

Plate 5 - Surface Water Station P2-G, dry season

Plate 6 - Surface Water Station P7-A, dry season

Plate 7 - Surface Water Station P7-B, dry season

Plate 8 - Surface Water Station P7-C, dry season


Plate 9 - Surface Water Station P8-A, dry season


Plate 10 - Surface Water Station P8-C, dry season

Plate 11 - Groundwater Station GW1

Plate 12 - Groundwater Station GW2

Plate 13 - Groundwater Station GW3

Plate 14 - Marine Water Station MW1, dry season

Plate 15 - Marine Water Station MW2, dry season

Plate 16 - Marine Water Station MW3, dry season


Plate 17 – Marine Water Station MW4, dry season

2.2.2.2 Results and Discussion

2.2.2.2.1 Surface Water, Sediment anf Groundwater Quality in Sta. Cruz Area (EISWestChinaMin, 2016)

Table 42 to *Table 44* present the results of physico-chemical and inorganics constituents for surface water, river sediments and ground water quality. Water samples were taken at the upstream, midstream and downstream along Mount Oro tributary (Patogo River). Grab sampling was employed. Weather condition at the time of sampling was sunny and fair. On site analyses done were pH, temperature and dissolved oxygen. Flow rate, sampling coordinates and river width were measured in each location. The collected samples were contained in cooler with ice and subjected for laboratory analysis to CRL. Figure 2-53 shows the baseline water sampling map. Results of upstream, midstream and downstream of surface water at table 2- 38 for pH, BOD, TSS, nitrates, metals (Cd, Cr+6, Pb) and coliform were within the allowable DENR standards, Class C. Oil & Grease results were obtained from EMB-DENR, R3. Average results were below 1.0 mg/L. Table 2-39 shows the river sediments results. Based on obtained data, chromium and nickel concentrations are significant which obviously this indicates that the area is rich in these types of minerals. Few traces of arsenic were found from bottom sediments. However, there are no reference standards for bottom sediments from DENR. Table 2-40 shows the sampling stations and coordinates of groundwater. Figure 2-54 presents the sampling map of the groundwater stations. For groundwater quality based on table 2-41, all measured parameters such as TDS, nitrate and metals were within the PNSDW DOH AO 2007-12 standards. It was noted that coliform bacteria exceeded the allowable Phil. National Standards for Drinking Water in all stations tested. The limits for total coliform and fecal coliform bacteria must be zero or none detection at all. Detection of coliform bacteria in drinking water indicates that the water is nonpotable and not intended for human consumption without employing the necessary water treatment. Fecal coliforms are considered a more accurate indication of human or animal waste contamination in drinking water. Sources of water come from shallow wells and hand pumps. Absence of appropriate domestic wastewater septic tank will cause proliferation of bacteria in the area and contamination in groundwater.

2.2.2.2.2 Surface Water Quality

Only six (6) out of ten (10) surface water stations had water during the dry season sampling. These stations are P2-C, P2-E, P7-A, P7-C, P8-A and P8-C. The remaining stations P2-D, P2-F, P2-G, and P7-B had no flowing water during the dry season sampling thus no samples were collected from these stations. It should be noted that stations P2-D, P2-F, and P7-B are located downstream of stations with flowing water particularly P2-C, P2-E, and P7-A, respectively. This is an indication that during the dry season, water coming from the headwaters may not reach the downstream portion of the stream.
Similarly, samples were not collected from all surface water stations during the wet season sampling due to inaccessibility of stations P2-C, P2-E, P7-A, and P7-C. The access roads going to these stations are traversed by rivers which are difficult and unsafe to cross during the wet season sampling period. Only the downstream portions of the rivers draining the Parcel 2 and Parcel 7 were accessible during the wet season sampling. These stations however, were dry during the dry season sampling. Only Stations P8-A and P8-C had their water sampled for both dry and wet season.

Dissolved oxygen for stations P2-E and P7-C were below the guideline value for Class C waters with DO values 2.74 mg/l and 4.04 mg/l, respectively during the dry season sampling. Water from these stations was almost stagnant during the time of in-situ analysis as can be seen in *Plate 3* and *Plate 8* thus the low DO levels. The rest of the stations had DO levels above the minimum guideline value for Class C.

Exceedances were also observed for the Fecal Coliform count in stations P2-E and P7-C during the dry season sampling and in stations P2-D, P2-F, P2-G, P7-B, P8-A and P8-C during the wet season sampling. Comparing the results for the dry and wet season sampling, significant increase in Fecal Coliform count can be observed for stations P8-A (17 MPN/100ml to 920,000 MPN/100ml) and P8-C (79 MPN/100ml to 35,000 MPN/100ml).

Water temperatures of stations P7-A, P8-A and P8-C slightly exceeded the upper limit of the guideline temperature range during the dry season sampling.

In terms of TSS, all samples collected during the dry season sampling exhibited very low TSS concentrations ranging from 3 mg/l to 9.5 mg/l. On the other hand, TSS levels during the wet season sampling were relatively higher with stations P2-F (TSS=104 mg/l) and P2-G (TSS=83 mg/l) exceeding the Class C guideline (80 mg/l) and P8-A (91 mg/l) exceeding the Class B guideline (65 mg/l) for TSS. This significant increase in TSS is expected during the wet season due to the erosion (by natural and anthropogenic causes) and siltation due to the increased surface runoff within the catchment brought about by rainfall.

In terms of metals, only the sample collected from P8-C during the wet season sampling (Hg=0.002 mg/l) exceeded the Class B guideline value for mercury. The rest of the samples had metal concentrations within the guideline values for all of the parameters. Traces of Ni and Mn were observed in some of the surface water samples. Other parameters As, Cd, Pb, and Hg (except P8-A wet season) had metal concentrations below the method detection limit (MDL).

2.2.2.2.3 Groundwater Quality

Parameter of concern for groundwater samples collected from the three (3) different stations is Fecal Coliform count which was observed to exceed the Class A water quality guideline (WQG). Other parameters were within the guideline values for Class A waters except Mn and Ni in wet season groundwater sample collected from GW3.

2.2.2.2.4 Marine Water Quality

Two (2) parameters of concern were observed for the marine water samples collected: Fecal Coliform and sulfate. The rest of the parameters were within the guideline values for Class SC waters. Fecal Coliform counts of samples collected during the dry season sampling were all below 200 MPN/100ml which is the Class SC guideline value. However, a significant increase in Fecal Coliform count were observed during the wet season sampling with values ranging from 350 MPN/100ml to 9,200 MPN/100ml exceeding the Class SC guideline value of 200 MPN/100ml. This is probably due to the runoff coming from the different catchment areas consisting of farms and built-up areas which eventually end up in the coastal waters during the rainy season. Sulfates were also found in high concentration in all of the marine water samples both for the wet and dry season ranging from 1,730 mg/l to 2,000 mg/l for the dry season samples and 943 mg/l to 1,190 mg/l for the wet season samples exceeding the 275 mg/l WQG for sulfate. One of the possible sources of sulfate in the marine waters could be the runoff coming from the fertilized agricultural lands which can be found within the flood plains of Candelaria and Sta. Cruz, Zambales.

Table 42 - Results of Surface Water Quality – Sta. Cruz Area (EISWestChinaMin, 2016)

Parameters	Methodology	Upstream	Midstream	Downstream	DENR Standards* Class "C"
Physico-chemical Constituents					
Flow rate, m/sec	Flow meter	0.63	0.67	0.90	---
pH	Electrometric (pH meter)	7.9	8.1	8.0	6.5-8.5
Temperature	Field method	25.8	27.0	27.4	max. of 3 deg. Rise
Dissolved Oxygen, mg/L	Winkler/Titrimetry	9.4	9.1	9.6	Min. of 5.0 mg/L
BOD, mg/L	Titrimetry	7	3	5	7(10)
Total Dissolved Solids, mg/L	Gravimetry	162	133	141	---
Total Suspended Solids, mg/L	Gravimetry	<2.5	<2.5	<2.5	Not more than 30 mg/L increase
Nitrate	Brucine Colorimetry	0.07	0.02	0.05	10
Metals					
Arsenic, mg/L	SDDC Colorimetry	<0.01	<0.01	<0.01	0.05
Cadmium, mg/L	Flame AAS	<0.006	<0.006	<0.006	0.01
Chromium hexavalent, mg/L	Colorimetry	<0.003	<0.003	<0.003	0.05
Lead, mg/L	Flame AAS	<0.04	<0.04	<0.04	0.05
Nickel, mg/L	Flame AAS	<0.03	<0.03	<0.03	---
Microbiology					
Total Coliform, MPN/100ml	Multiple Tube Fermentation Technique	1,600	540	49	5,000
Fecal Coliform, MPN/100ml	Multiple Tube Fermentation Technique	49	540	23	---
Oil & Grease	Gravimetry	<1.0 mg/L	Source: EMB-DENR, R3 (2013)		2.0

*DENR Administrative Order No. 34, Series of 1990

Table 43 - Results of River Sediments taken at Sta. Cruz Area (EISWestChinaMin, 2016)

Parameters	Methodology	Upstream	Midstream	Downstream
Inorganic Constituents				
Arsenic, mg/kg	Hydride AAS	0.1	0.07	0.08
Cadmium, mg/kg	Flame AAS	<0.1	<0.1	<0.1
Chromium, mg/kg	Colorimetry	276	222	290
Lead, mg/kg	Flame AAS	<0.8	<0.8	<0.8
Nickel, mg/kg	Flame AAS	537	1,310	3,160
Nitrate, mg/kg	Colorimetry	4.8	1.6	3.2

Table 44 - Results of Ground Water Quality taken at Sta. Cruz Area (EISWestChinaMin, 2016)

Parameters	Methodology	Station I	Station II	PNSDW Standards
Physico-chemical Constituents				
pH	Electrometric (pH meter)	5.8	5.9	6.5-8.5
Temperature	Field method	28.6	28.1	---
Total Dissolved Solids, mg/L	Gravimetry	398	142	500
Nitrate, mg/L	Cadmium Reduction Colorimetry	20	18	50
Metals				
Arsenic, mg/L	Hydride AAS	<0.001	<0.001	0.05
Cadmium, mg/L	Flame AAS	<0.003	<0.003	0.003
Chromium, mg/L	Flame AAS	<0.02	<0.02	0.05
Lead, mg/L	Graphite AAS	0.004	<0.0001	0.01
Nickel, mg/L	Flame AAS	<0.01	<0.01	0.02
Microbiology				
Total Coliform, MPN/100ml	Multiple Tube Fermentation Technique	>23	>23	<1.1
Fecal Coliform, MPN/100ml	Multiple Tube Fermentation Technique	>23	>23	<1.1

Table 45 - Results of Surface Water Quality Monitoring Candelaria Area

Parameter	Unit	Sampling Date	Sampling Station / Results								DAO 2016-08 Guideline Values Class C	Sampling Station / Results		DAO 2016-08 Guideline Values Class B
			P2-C Balin Buaya River, inside Parcel 2	**P2-D** Balin Buaya River downstream, at the western boundary of Parcel 2	**P2-E** Sto. Niño Cave River 1 (north tributary), within Parcel 2	**P2-F** Sto. Niño Cave River 1 (north tributary) downstream, draining Parcel 2	**P2-G** Sto. Niño Cave River 2 (south tributary), draining Parcel 2	**P7-A** Duplac River within Parcel 7	**P7-B** Duplac River downstream of Parcel 7	**P7-C** Pader River downstream of Parcel 7		**P8-A** North Lauis River, main, upstream of the tributary draining Parcel 8	**P8-C** North Lauis River, main, downstream of confluence of tributary draining Parcel 8	
PRIMARY PARAMETERS														
Dissolved Oxygen (minimum)	mg/L	April 27-28, 2018	7.05	(a)	2.74	(a)	(a)	7.05	(a)	4.04	**5**	6.69	7.3	**5**
		June 11-12, 2018	*(b)*	*6.70*	*(b)*	*6.98*	*6.66*	*(b)*	*7.07*	*(b)*		*7.08*	*6.65*	
Fecal Coliforms	MPN/100mL	April 27-28, 2018	31	(a)	920	(a)	(a)	70	(a)	2,400	**200**	17	79	**100**
		June 11-12, 2018	*(b)*	*3,500*	*(b)*	*3,500*	*13,000*	*(b)*	*3,500*	*(b)*		*920,000*	*35,000*	
Nitrate (NO_3-N)	mg/L	April 27-28, 2018	0.08	(a)	0.1	(a)	(a)	0.1	(a)	0.2	**7**	0.2	0.2	**7**
		June 11-12, 2018	*(b)*	*0.4*	*(b)*	*0.3*	*0.3*	*(b)*	*0.6*	*(b)*		*0.3*	*0.2*	
pH		April 27-28, 2018	8.65	(a)	7.37	(a)	(a)	8.55	(a)	7.53	**6.5-9.0**	8.37	8.43	**6.5-8.5**
		June 11-12, 2018	*(b)*	*8.58*	*(b)*	*8,44*	*8.19*	*(b)*	*8.79*	*(b)*		*8.42*	*8.53*	
Temperature	°C	April 27-28, 2018	29.1	(a)	29.0	(a)	(a)	32.2	(a)	28.8	**25-31**	30.8	32.7	**26-30**
		June 11-12, 2018	*(b)*	*25.7*	*(b)*	*27.0*	*27.9*	*(b)*	*25.7*	*(b)*		*26.2*	*26.7*	
Total Suspended Solids (TSS)	mg/L	April 27-28, 2018	3.0	(a)	4.0	(a)	(a)	3.7	(a)	9.5	**80**	5.0	4.0	**65**
		June 11-12, 2018	*(b)*	*34*	*(b)*	*104*	*83*	*(b)*	*64*	*(b)*		*91*	*17*	
SECONDARY PARAMETERS – Inorganics														
Sulfate (SO_4)	mg/L	April 27-28, 2018	<5.0	(a)	8.9	(a)	(a)	<5.0	(a)	8.1	**275**	<5.0	<5.0	**250**
		June 11-12, 2018	*(b)*	*<5.0*	*(b)*	*8.2*	*6.3*	*(b)*	*7.3*	*(b)*		*<5.0*	*<5.0*	
SECONDARY PARAMETERS – Metals														
Arsenic	mg/L	April 27-28, 2018	<0.008	(a)	<0.008	(a)	(a)	<0.008	(a)	<0.008	**0.02**	<0.008	<0.008	**0.01**
		June 11-12, 2018	*(b)*	*<0.01*	*(b)*	*<0.01*	*<0.01*	*(b)*	*<0.01*	*(b)*		*<0.01*	*<0.01*	
Cadmium	mg/L	April 27-28, 2018	<0.001	(a)	<0.001	(a)	(a)	<0.001	(a)	<0.001	**0.005**	<0.001	<0.001	**0.003**
		June 11-12, 2018	*(b)*	*<0.003*	*(b)*	*<0.003*	*<0.003*	*(b)*	*<0.003*	*(b)*		*<0.003*	*<0.003*	

Parameter	Unit	Sampling Date	Sampling Station / Results								DAO 2016-08 Guideline Values Class C	Sampling Station / Results		DAO 2016-08 Guideline Values Class B
			P2-C Balin Buaya River, inside Parcel 2	P2-D Balin Buaya River downstream, at the western boundary of Parcel 2	P2-E Sto. Niño Cave River 1 (north tributary), within Parcel 2	P2-F Sto. Niño Cave River 1 (north tributary) downstream, draining Parcel 2	P2-G Sto. Niño Cave River 2 (south tributary), draining Parcel 2	P7-A Duplac River within Parcel 7	P7-B Duplac River downstream of Parcel 7	P7-C Pader River downstream of Parcel 7		P8-A North Lauis River, main, upstream of the tributary draining Parcel 8	P8-C North Lauis River, main, downstream of confluence of tributary draining Parcel 8	
Lead (Pb)	mg/L	April 27-28, 2018	<0.005	(a)	<0.005	(a)	(a)	<0.005	(a)	<0.005	**0.05**	<0.005	<0.005	**0.01**
		June 11-12, 2018	*(b)*	*<0.05*	*(b)*	*<0.05*	*<0.05*	*(b)*	*<0.05*	*(b)*		*<0.05*	*<0.05*	
Manganese (Mn)	mg/L	April 27-28, 2018	0.008	(a)	<0.003	(a)	(a)	0.01	(a)	0.04	**0.2**	0.007	0.006	**0.2**
		June 11-12, 2018	*(b)*	*0.04*	*(b)*	*0.08*	*<0.01*	*(b)*	*0.08*	*(b)*		*<0.01*	*<0.01*	
Mercury (Hg)	mg/L	April 27-28, 2018	<0.0002	(a)	<0.0002	(a)	(a)	<0.0002	(a)	<0.0002	**0.001**	<0.0002	<0.0002	**0.001**
		June 11-12, 2018	*(b)*	*<0.0002*	*(b)*	*<0.0002*	*<0.0002*	*(b)*	*<0.0002*	*(b)*		*<0.0002*	*0.002*	
Nickel (Ni)	mg/L	April 27-28, 2018	<0.003	(a)	0.01	(a)	(a)	0.006	(a)	0.04	**0.2**	<0.003	<0.003	**0.04**
		June 11-12, 2018	*(b)*	*<0.03*	*(b)*	*0.07*	*<0.03*	*(b)*	*0.1*	*(b)*		*<0.03*	*<0.03*	
SECONDARY PARAMETERS – Organics														
Oil & Grease	mg/L	April 27-28, 2018	1.3	(a)	0.6	(a)	(a)	1.6	(a)	0.9	**2**	0.9	0.7	**1**
		June 11-12, 2018	*(b)*	*0.7*	*(b)*	*0.9*	*1.4*	*(b)*	*0.6*	*(b)*		*0.9*	*1.0*	
ADDITIONAL PARAMETERS														
Total Dissolved Solids (TDS)	g/L	April 27-28, 2018	1.37	(a)	2.72	(a)	(a)	1.64	(a)	2.17	**No guideline**	1.09	1.03	**No guideline**
		June 11-12, 2018	*(b)*	*1.19*	*(b)*	*1.28*	*1.03*	*(b)*	*1.10*	*(b)*		*0.732*	*0.746*	
Total Coliforms	MPN/100mL	April 27-28, 2018	110	(a)	1,600	(a)	(a)	170	(a)	3,500	**No guideline**	79	130	**No guideline**
		June 11-12, 2018	*(b)*	*3,500*	*(b)*	*11,000*	*13,000*	*(b)*	*5,400*	*(b)*		*920,000*	*54,000*	
Chemical Oxygen Demand (COD)	mg/L	April 27-28, 2018	16	(a)	20	(a)	(a)	70	(a)	18	**No guideline**	13	16	**No guideline**
		June 11-12, 2018	*(b)*	*102*	*(b)*	*13*	*30*	*(b)*	*30*	*(b)*		*16*	*9.3*	

Table 46 - Results of Groundwater Quality Monitoring

Parameter	Unit	Sampling Date	Sampling Station / Results			DAO 2016-08
			GW1 Brgy. Taposo	GW2 Brgy. Pinagrealan	GW3 Brgy. Sinabacan	Guideline Values Class A
PRIMARY PARAMETERS						
Fecal Coliforms	MPN/100mL	April 27-28, 2018	16	>23	<1.1	**<1.1**
		June 11-12, 2018	*>23*	*>23*	*>23*	
Nitrate (NO_3-N)	mg/L	April 27-28, 2018	0.2	0.2	0.2	**7**
		June 11-12, 2018	*0.8*	*0.5*	*0.5*	
pH		April 27-28, 2018	7.41	7.53	7.82	**6.5-8.5**
		June 11-12, 2018	*7.47*	*7.69*	*8.05*	
Temperature	°C	April 27-28, 2018	27.7	29.7	28.9	**26-30**
		June 11-12, 2018	*26.7*	*28.5*	*27.2*	
Total Suspended Solids (TSS)	mg/L	April 27-28, 2018	3.0	4.0	3.7	**80**
		June 11-12, 2018	*4.3*	*3.3*	*3.0*	
SECONDARY PARAMETERS – Inorganics						
Sulfate (SO_4)	mg/L	April 27-28, 2018	<5.0	<5.0	<5.0	**250**
		June 11-12, 2018	*5.9*	*5.6*	*<5.0*	
SECONDARY PARAMETERS – Metals						
Arsenic	mg/L	April 27-28, 2018	<0.008	<0.008	<0.008	**0.01**
		June 11-12, 2018	*<0.008*	*<0.008*	*<0.008*	
Cadmium	mg/L	April 27-28, 2018	<0.001	<0.001	<0.001	**0.003**
		June 11-12, 2018	*<0.003*	*<0.003*	*<0.003*	
Lead (Pb)	mg/L	April 27-28, 2018	<0.005	<0.005	<0.005	**0.01**
		June 11-12, 2018	*<0.005*	*<0.005*	*<0.005*	
Manganese (Mn)	mg/L	April 27-28, 2018	<0.003	0.004	0.04	**0.2**

Parameter	Unit	Sampling Date	Sampling Station / Results			DAO 2016-08 Guideline Values Class A
			GW1 Brgy. Taposo	GW2 Brgy. Pinagrealan	GW3 Brgy. Sinabacan	
		June 11-12, 2018	*<0.01*	*0.03*	*1.7*	
Mercury (Hg)	mg/L	April 27-28, 2018	<0.0002	<0.0002	<0.0002	**0.001**
		June 11-12, 2018	*<0.0002*	*<0.0002*	*<0.0002*	
Nickel (Ni)	mg/L	April 27-28, 2018	<0.003	0.004	0.01	**0.02**
		June 11-12, 2018	*<0.01*	*<0.01*	*0.2*	
SECONDARY PARAMETERS – Organics						
Oil & Grease	mg/L	April 27-28, 2018	0.6	0.6	0.8	**1**
		June 11-12, 2018	*0.5*	*0.3*	*0.4*	
ADDITIONAL PARAMETERS						
Total Dissolved Solids	g/L	April 27-28, 2018	2.62	1.37	3.62	**No guideline**
		June 11-12, 2018	*2.29*	*1.35*	*3.59*	
Total Coliforms	MPN/100mL	April 27-28, 2018	>23	>23	<1.1	**No guideline**
		June 11-12, 2018	*>23*	*>23*	*>23*	
Conductivity	mS/m	April 27-28, 2018	0.523	0.272	0.727	**No guideline**
		June 11-12, 2018	*0.455*	*0.275*	*0.719*	

Table 47 - Results of Marine Water Quality Monitoring

Parameter	Unit	Sampling Date	Sampling Station / Results				DAO 2016-08 Guideline Values Class SC
			MW1 Near Potipot Island and Agnacon River outlet	MW2 Near Candelaria Marine Fish Sanctuary	MW3 Near San Vicente River outlet/mouth	MW4 Near North Lauis River/Masinloc Power Plant	
PRIMARY PARAMETERS							
Dissolved Oxygen (minimum)	mg/L	April 27-28, 2018	6.14	6.70	6.67	6.68	**5**
		June 11-12, 2018	*6.06*	*6.09*	*6.25*	*6.26*	

Parameter	Unit	Sampling Date	Sampling Station / Results				DAO 2016-08 Guideline Values Class SC
			MW1 Near Potipot Island and Agnacon River outlet	MW2 Near Candelaria Marine Fish Sanctuary	MW3 Near San Vicente River outlet/mouth	MW4 Near North Lauis River/Masinloc Power Plant	
Fecal Coliforms	MPN/100mL	April 27-28, 2018	13	<1.8	<1.8	<1.8	**200**
		June 11-12, 2018	*350*	*9,200*	*1,600*	*2,400*	
Nitrate (NO_3-N)	mg/L	April 27-28, 2018	0.3	0.1	0.3	0.3	**10**
		June 11-12, 2018	*0.4*	*0.07*	*0.07*	*0.05*	
pH		April 27-28, 2018	8.19	8.21	8.25	8.22	**6.5-8.5**
		June 11-12, 2018	*8.20*	*8.05*	*8.16*	*7.89*	
Temperature	°C	April 27-28, 2018	30.7	30.5	30.4	30.5	**25-31**
		June 11-12, 2018	*29.1*	*29.6*	*29.6*	*29.7*	
Total Suspended Solids (TSS)	mg/L	April 27-28, 2018	9.8	7.0	13	12	**80**
		June 11-12, 2018	15	16	17	3.7	
SECONDARY PARAMETERS – Inorganics							
Sulfate (SO_4)	mg/L	April 27-28, 2018	2,000	1,730	1,760	1,770	**275**
		June 11-12, 2018	989	943	1,170	1,190	
SECONDARY PARAMETERS – Metals							
Arsenic	mg/L	April 27-28, 2018	<0.008	<0.008	<0.008	<0.008	**0.02**
		June 11-12, 2018	*<0.008*	*<0.008*	*<0.008*	*<0.008*	
Cadmium	mg/L	April 27-28, 2018	<0.001	<0.001	<0.001	<0.001	**0.005**
		June 11-12, 2018	*<0.001*	*<0.001*	*<0.001*	*<0.001*	
Lead (Pb)	mg/L	April 27-28, 2018	<0.005	<0.005	<0.005	<0.005	**0.05**
		June 11-12, 2018	*<0.005*	*<0.005*	*<0.005*	*<0.005*	
Manganese (Mn)	mg/L	April 27-28, 2018	0.009	0.007	0.007	0.005	**0.4**
		June 11-12, 2018	*<0.003*	*0.004*	*0.004*	*<0.003*	
Mercury (Hg)	mg/L	April 27-28, 2018	<0.0002	<0.0002	<0.0002	<0.0002	**0.002**

Parameter	Unit	Sampling Date	Sampling Station / Results				DAO 2016-08 Guideline Values Class SC
			MW1 Near Potipot Island and Agnacon River outlet	MW2 Near Candelaria Marine Fish Sanctuary	MW3 Near San Vicente River outlet/mouth	MW4 Near North Lauis River/Masinloc Power Plant	
		June 11-12, 2018	*<0.0002*	*<0.0002*	*<0.0002*	*<0.0002*	
Nickel (Ni)	mg/L	April 27-28, 2018	<0.003	<0.003	<0.003	<0.003	**0.06**
		June 11-12, 2018	*<0.003*	*<0.003*	*<0.003*	*<0.003*	
SECONDARY PARAMETERS – Organics							
Oil & Grease	mg/L	April 27-28, 2018	1.0	0.5	1.1	0.6	**3**
		June 11-12, 2018	*0.5*	*0.5*	*0.7*	*0.6*	
ADDITIONAL PARAMETERS							
Total Coliforms	MPN/100mL	April 27-28, 2018	33	<1.8	<1.8	<1.8	**No guideline**
		June 11-12, 2018	*350*	*16,000*	*1,600*	*2,400*	

2.2.2.3 Impact Assessment

2.2.2.3.1 <u>Erosion and Siltation</u>

Stripping and clearing of overburden and ore mining will generate large amounts of loose materials that can be easily eroded by surface runoff especially during the wet season. If not managed properly, these loose materials as well as the opened up areas can be easily washed away or eroded and cause siltation of the receiving bodies of water particularly the rivers/creeks draining the project area and the coastal areas of Candelaria and Sta. Cruz.

To mitigate these impacts, a Sediment and Erosion Control Plan must be developed and implemented. The plan must include construction of a drainage system which will be connected to adequately-sized and properly designed sedimentation ponds so that clean water/runoff coming from the hilly areas east of the project site will be diverted away from the disturbed areas while the impacted water/silted runoff coming from the mine area will be conveyed to the sedimentation ponds for silt removal prior to release to the receiving water bodies – creeks/rivers directly draining the project area. Access roads and haul roads must at least be graveled and be provided with lined drains. A combination of vegetative and engineering measures to control erosion must also be implemented especially in areas with critical slopes.

Progressive rehabilitation will also be implemented to minimize the exposed areas at a given time. Sufficient buffers from the natural waterways shall be set. One of the contributors to sedimentation is river bed and river bank erosion in the area which was observed during water quality assessment/sampling conducted. Vegetative and engineering measures must be implemented at least for the rivers/natural channels within the project boundaries for stream stability.

2.2.2.3.2 Generation of wastes/wastewater

The project operation will generate various kinds of wastes primarily solid wastes and sewage from the Admin complex, hazardous wastes from the Motor Pool/Shop, and wastewater from the processing plant. Improperly managed wastes may lead to the contamination of surface water and groundwater.

The Admin Complex particularly the Housing Area shall be provided with septic tanks. Sewage coming from the Admin Complex must be treated prior to release to the environment.

A hazardous waste facility must be constructed to temporarily store the hazardous wastes generated from the site/operatons prior to disposal through a DENR-accredited hauler/treater.

The processing plant will be using water for cooling of nickel granules prior to pelletizing. Any wastewater coming out of the process must be treated accordingly prior to discharge.

Facilities handling hazardous materials such as fuel i.e. Motorpool/shop shall have oil and water separators installed.

2.2.3 Freshwater Ecology

2.2.3.1 Existing ECC (EISWestChinaMin, 2016)

Bottom river sediment samples were collected upstream, midstream and downstream along Mount Oro. Random sampling using Quadrat method at 0.25 square meter quadrat was applied transecting both sides of the river. Grab sediment samples were collected using Eckman dredge sampler which were pass through the plankton nets. During sampling, presence of juvenile shrimps was observed. Water proof labels and protective container were used. Samples were preserved with ethanol prior to laboratory analysis. *Table 48* and *Table 49*present the result of macroinvertebrates and plankton determinations from river sediments. Based on data obtained, there were no presence of zooplanktons and phytoplanktons along tributary of Mt. Oro creek.*Melanoides tuberculata*are abundant at upstream and midstream stations. Rare presence of *Bithynia tentaculata*and*Carldina sp.*are obtained along midstream& downstream respectively.

Table 48 - Results of Macroinvertebrates for River Sediments

Sample ID	***Analyses***	***Species***	***Total Counts***	***Coded Abundance***	***Total No. of Species***
Upstream Sediments	Macroinvertebrates Total count and Coded Abundance	*Melanoides tuberculata*	31	A	31
Midstream Sediments	Macroinvertebrates Total count and Coded Abundance	*Melanoides tuberculata*	21	A	22
	Macroinvertebrates Total count and Coded Abundance	*Bithynia tentaculata*	1	R	
Downstream Sediments	Macroinvertebrates Total count and Coded Abundance	*Carldina sp.*	2	R	2

Legend: R – Rare, 1-4; C – Common, 5-19; A – Abundant, 20-99; VA – Very Abundant, 100-499; VVA or XA – Very, very abundant or extra abundant, 500+ animals per sample.

Table 49 - Results of Planktons for River Sediments

Sample ID	**Analyses**	**Species**	**Total Counts**
Upstream Sediments	Plankton (Zooplankton and Phytoplankton)	0	0
Midstream Sediments	Plankton (Zooplankton and Phytoplankton)	0	0
Downstream Sediments	Plankton (Zooplankton and Phytoplankton)	0	o

2.2.3.2 Methodology

Four river systems that may likely be impacted by the project were surveyed namely: Duplac River, Balin Buaya River, St. Niño River, and North Lauis River. Field survey was carried out through direct observation and field sampling. Biological indicators such as benthic macroinvertebrates, zooplankton, phytoplankton, and fish were observed, collected and analyzed in order to assess the overall impact of the project.

2.2.3.2.1 Benthic macroinvertebrates

Benthic macroinvertebrates are useful biological indicators of changes in the aquatic ecosystems. These organisms are mostly preferred in monitoring the health of stream and river systems because they have varying sensitivities to changes in water quality. They are also easily collected due to their relatively sedentary life cycle.

Samples were collected using a 0.5 m^2 rectangular kick net, with a 500 µm mesh size. Each sample was taken manually by vigorously kicking the sediments upstream of the net for 30 seconds. Composite samples collected from the pool, riffle, and run habitats were combined and stored in plastic containers and were immediately fixed with 95% ethanol. These were brought to the laboratory for further analysis and identification. A dissecting microscope was used to sort morphologically similar individuals. After sorting, the taxonomic family level of the macroinvertebrates will be identified using the keys of Dudgeon (1999), and the Mekong River Commission (2006).

Using the macroinvertebrate data, the following biological metrics were calculated: (i) total invertebrate density, (ii) taxon richness, and (iii) Simpson's index of Diversity. Moreover, the current condition of the four river systems was determined using the Hilsenhoff's Family Biotic Index (HBI), a biotic index for assessing organic and nutrient pollution using tolerance values of arthropod families (Hilsenhoff, 1988).

2.2.3.2.2 Plankton

Plankton organisms respond rapidly to environmental changes, which makes them very useful in evaluating water quality. All species or assemblages tolerate a limited range of chemical, physical, and biological conditions. Monitoring these biological communities is relatively inexpensive and reliable assessment of the condition of aquatic systems.

Plankton samples will be obtained by towing a 30-cm wide plankton net with a mesh size of 64 microns, horizontally at a distance of about 1m. This will be done ten times; filtering approximately 100L of surface water. A total of 12 samples of zooplankton and phytoplankton were collected from the six sampling stations. Two replicates were drawn from each site and were placed in properly- labeled 500 ml screw-capped bottles. These were immediately fixed with formaldehyde (5% by volume) and brought to the laboratory for processing and further analysis.

Zooplankton and phytoplankton samples were filtered and concentrated to 50ml. Enumeration was done by transferring 1ml aliquot sample in the Sedgewick-Rafter counting chamber, and then observed under a compound microscope. Plankton were identified to the lowest possible taxa using taxonomic keys such as those of Mamaril et al. (1986), Segers (2004; 2007) and Bellinger and Sigee (2010). Zooplankton density was estimated and expressed as number of individuals/m^3, while phytoplankton density was expressed as cells/m^3.

Diversity indices such as: (i) total plankton density, (ii) taxon richness, and (iii) Shannon index of Diversity, were calculated using Paleontological Statistical Package for Education and Data Analysis (PAST) version 2.17c.

2.2.3.2.3 Fish

Secondary biological data (freshwater fish and other fauna) were gathered through literature search from government and private institutions. Chance interviews and queries were also undertaken among local residents to supplement the information that are vital to the study.

Plate 18 - Plankton collection using conical plankton net

Plate 19 - Benthic macroinvertebrates collection using rectangular kick net

Table 50 - Diversity and Biotic Indices of Plankton and Benthic Macroinvertebrates

Index	Formula/definition	Implication/interpretation	References
Total species abundance	Is the density or number of aquatic macro invertebrates per unit area	Abundance decreases when flow is high, an increase in fine sediment	Barbour et.al., 1999 & Vinson, 2000
Species or taxa Richness	Total number of species present; reflects the health of the community through a measurement of the variety of taxa present	Species richness increases with increasing habitat diversity, suitability and water quality 26= not impacted 19-26=slightly impacted 11-18=moderately impacted 0-10=severely impacted	Plafkin et.al., 1989
	H'= Σ (ni/N)(log ni/N)	> 4= clean water 3-4=slightly polluted	

Index	Formula/definition	Implication/interpretation	References
Shannon-Wiener Diversity Index (H')		2-3=moderately polluted < 2=very polluted	Shannon & Wiener, 1963 and Trivedi, 1979
Palmer pollution Index	The level of organic pollution can be determined by studying the algae present in water samples	0-10=Lack of organic pollution 11-15=Moderate organic pollution 16-20 = probable high organic pollution 21 or more = high organic pollution	Palmer, 1969

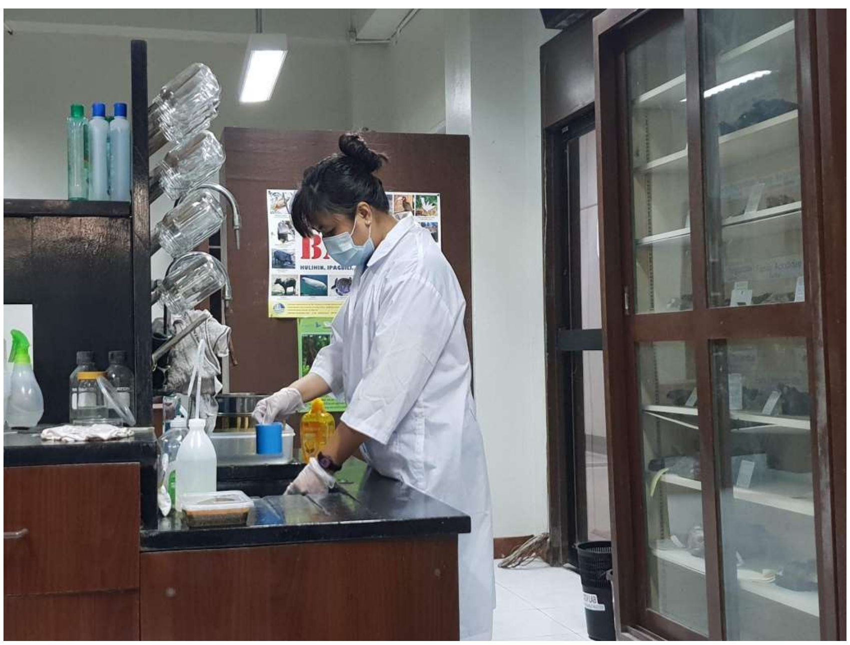


Plate 20 - Processing and filtering of plankton samples

Plate 21 - Identification and quantification of plankton using compound microscope

Table 51 - Summary of Habitat and Environmental Parameters of Freshwater Ecology Component Sampling Stations

Water quality station	**Station 1** (P7B)	**Station 2** (P2D)	**Station 3** (P2F)	**Station 4** (P2G)	**Station 5** (P8A)	**Station 6** (P8C)
River System	Duplac River	Balin Buaya River	Sto. Niño Cave River		North Lauis River	North Lauis River
Locality	Brgy. Sinabacan, Candelaria , Zambales	Brgy. San Roque, Candelaria , Zambales	Brgy. Taposo, Candelaria , Zambales	Brgy. Taposo, Candelaria, Zambales	Brgy. Pinagreala n, Candelaria , Zambales	Brgy. Pinagreala n, Candelaria, Zambales
GPS Coordinates	N 15° 40’ 06.3” E 119° 57’ 55.51”	N 15° 39’ 14.8” E 119° 58’ 02.39”	N 15° 37’ 40.8” E 119° 58’ 25.72”	N 15° 36’ 58.45” E 119° 58’ 00.23”	N 15° 35’ 37.83” E 120° 57’ 03.6”	N 15° 35’ 37.4” E 119° 59’ 31.49”

Current weather	Heavy rain	Drizzly	Heavy rain	Light rain	Light rain	Drizzly
Stream flow (m/s)	0.8-1.6	0.6-0.9	0.6-1.0	0.4-0.7	0.4-0.6	0.2-0.5
Substrate	Gravel/rocks in stream	Gravel/rocks in stream	Boulders, Gravel/rocks in stream	Gravel/rocks, clay	Gravel/rocks in stream	Gravel/rocks, clay
Land-use	Forest (intermittent river)	Forest (intermittent river)	Recreational use	Irrigation for agricultural areas	Nearby small scale mining activity	Nearby small scale mining activity
Dissolved oxygen (mg/L)	7.07	6.7	6.98	6.66	7.08	6.65
Temperature (C)	25.7	25.7	27	27.9	26.2	26.7
pH	8.76	8.58	8.19	8.19	8.42	8.53
Total dissolved solids (g/L)	1.1	1.19	1.28	1.03	732	746
Conductivity(µs)	22.1	0.239	255	0.207	146.3	149.3
Salinity(ppt)	1.2	1.3	1.5	1.2	0.8	0.8

2.2.3.3 Results and Discussion

2.2.3.3.1 Threat to Existence and Loss of Important Species and Habitat

The freshwater ecology assessment focused on three functional aquatic groups – phytoplankton, zooplankton and benthic macroinvertebrates present in the six different stations in the proposed project site. Phytoplankton are the base of the aquatic food web, which serve as food for higher organisms in different aquatic ecosystems. In freshwater systems, a wide variety of phytoplankton species exist. Certain species are directly consumed by zooplankton grazers; some indicates organic pollution, while others are toxic when in bloom. Knowledge of the types of species present in a particular river system may help in understanding the management strategies needed in monitoring project impacts.

Phytoplankton are used as bioindicators because, overall, they are more reactive to the changes in the environment than other organisms. Furthermore, they are better than fishes and macroinvetebrates as bioindicators in terms of their presence before and after (to some extent) environmental changes. The state of the phytoplankton community is resultant of the nutrient load of the water. Their abundance and diversity reflect water quality and was used to derive assessment protocols. These features make them the best bioindicators in aquatic ecosystems (Pourafrasyabi and Ramezanpour 2014). Additionally, they are used because they are straightforward, can quantitatively describe water quality, are applicable in a wide area, and provide information on background conditions and natural variability (Onyema 2013).

Zooplankton are microscopic organisms that are also crucial in aquatic food webs. As primary consumers, they respond strongly to environmental changes. Certain species are highly sensitive to changes in nutrient cycling, temperature, pH and variable environmental conditions. Due to their unique responses to certain environmental dynamics, zooplankton are effective bioindicators, thus they are widely used to measure the impact of disturbance in aquatic ecosystems.

Fish species and their larvae rely on the density and distribution of plankton for survival. The population dynamics of phytoplankton and zooplankton affects the breeding success of nekton. Variations in river channels such as dams and changes in water current in the river systems may pose a threat to the existence of locally important fishes.

Benthic macroinvertebrates, like plankton, are useful biological indicators of changes in the aquatic systems. The main advantages of using macroinvertebrates is their life span of up to 1-2 years, they are relatively sedentary, have varying sensitivities to water quality changes and they are easily collected and identified. Benthic macroinvertebrates are grouped in three categories, (1) pollution sensitive organisms, which are found in good quality water; (2) somewhat pollution tolerant organisms can exist in good or fair quality water; and (3) pollution tolerant organisms that can survive in any quality of water. The current condition of a water system can be described by studying the composition, abundance and diversity of benthic macroinvertebrates present.

In the construction phase of the proposed plant and mining site, activities such as earth moving and vegetation removal within the development area will potentially impact the river systems. Loss of canopy cover, siltation and sediment runoff may be a source of threat to existence of locally important species. Appropriate erosion control measures will be implemented particularly during high precipitation periods. Another possible hazard that may impact the water quality is fuel and oil leaks from construction vehicles and other equipment. All machinery and equipment will be checked regularly, and any spilled oil or fuel will be collected, stored properly, and disposed by accredited haulers.

As part of the monitoring program, freshwater ecosystem monitoring will be conducted congruently to ensure the minimal impacts of the project in freshwater organisms, and water quality in river systems.

2.2.3.3.2 Threat to abundance, frequency and distribution of species

2.2.3.3.2.1 Benthic macroinvertebrates

A total of 5 families of benthic macroinvertebrates were identified in the samples collected from the various rivers investigated. The benthic macrofauna is composed of 50% Insecta, 33% of Gastropoda, and 17% of Bivalvia as shown in *Figure 70***.**

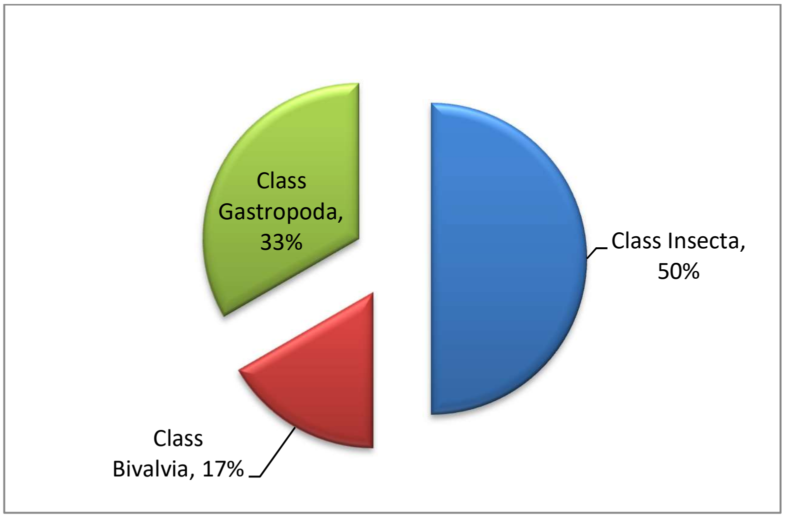


Figure 70 - Relative abundance of benthic macroinvertebrate communities

Chironomidae or non-biting midges can be an important freshwater indicator. These worm-like organisms have a visible head and 2 pairs of legs. They are found in sediments and feed on algae and organic materials. The larvae of some species are quite tolerant to pollution and are often indicative of poor water quality.

Gerridae and Hydrophysidae are common in streams, ponds and river habitats. They are both sensitive to certain contaminants or pollutants. Examining their population in river systems may help in assessing the water quality.

Cyrenidae or previously known as Family Corbiculidae are bivalves which inhabit in shallow flowing rivers. Bivalvia species are filter feeders. They are not selective, feeding opportunistically on unicellular algae and plant detritus suspended in the water column. Cyrenidae can play a significant role in local food webs by increasing the flux of organic and inorganic matter to riverbeds, which in turn influences macroinvertebrate assemblages.

Lymnaeidae are scrapers feeding on algae. They occur in slow flowing or still waters where they thrive in mud and shallow waters. These organisms can live in waters with low dissolved oxygen and can thrive in eutrophic conditions.

Table 52 summarizes the taxa recorded from the rivers, their distribution and diversity. Diversity is one way to detect water quality problems, like how the presence or absence of macroinvertebrate species shows the state of the quality of the water (Kripa et al. 2013). It refers to the number of different kinds of organisms found in a biological community. In general, communities with high diversity are more stable. Pollution and/or frequent habitat disturbance can displace intolerant organisms, and therefore reduce diversity. So if an area becomes polluted or disturbed, the total number of organisms may stay the same but species diversity may decrease. (Sanguansin, 1981; and Soata, 2000).

Table 52 - Composition, distribution and abundance of benthic macroinvertebrates in Candelaria, Zambales (June, 2018)

TAXA	*Station 1*	*Station 2*	*Station 3*	*Station 4*	*Station 5*	*Station 6*
Phylum Arthropoda						
Class Insecta	0	0	0	0	2	1
Family Chironomidae	0	0	0	0	1	0
Family Gerridae	0	0	0	0	1	0
Family Hydropsychidae	0	0	0	0	1	0
Phylum MOLLUSCA						
Class Bivalvia	0	0	0	0	1	0
Family Cyrenidae	0	0	0	0	1	0
Class Gastropoda	0	0	0	0	1	1
Family Lymnaeidae	0	0	0	0	1	1
Taxa Richness	0	0	0	0	5	3
Total Individuals					6	3
Dominance_D					0.2222	0.3333
Simpson_1-D					0.7778	0.6667
Shannon_H					1.561	1.099
Evenness_e^H/S					0.9524	1

Figure 71 shows the density (individuals/m^2) of benthic organisms in the proposed project site. The total number of individuals collected from the rivers surveyed was 9 ind/m^2, which were only present in Stations 5 and 6. The low frequency and diversity values of benthic macroinvertebrates may be due to the nature of the rivers surveyed. Stations 1, 2, 3, and 4 are intermittent rivers with no water flowing during the dry season.

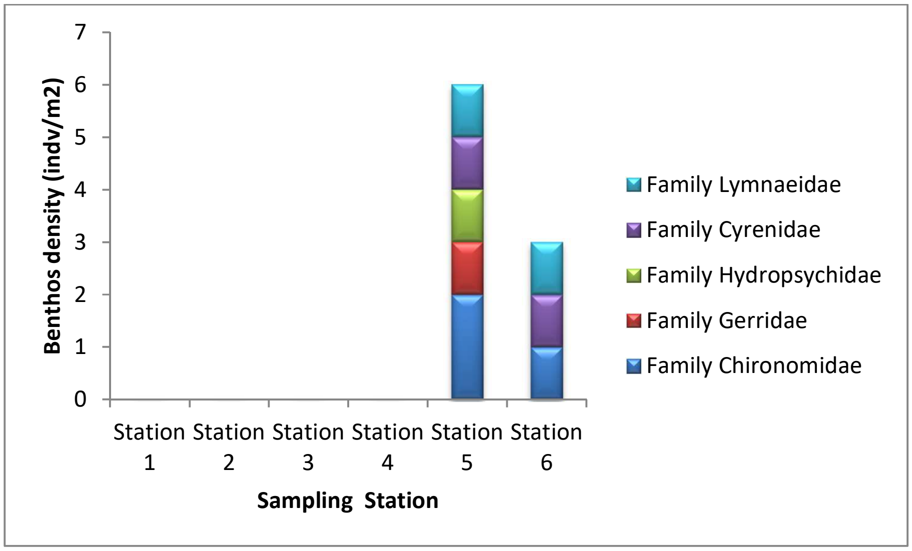


Figure 71 - Benthic macroinvertebrate density across 6 sampling stations

The benthic macroinvertebrates collected in the proposed project site are common in freshwater lotic environments and their distribution reflected this.

Plate 22 - Some benthic macroinvertebrates observed. (left) Family Lymnaeidae, (right) Family Hydropsychidae

2.2.3.3.2.2 Phytoplankton

The phytoplankton community structure of the rivers within the proposed site hosts a variety of species. A total of 16 taxa were identified. As presented in *Figure 72* **,** Chlorophyta or green algae were the major group comprising the phytoplankton population (58%). Cyanophyta or blue-green algae followed, with 26%. Relatively low abundance was exhibited by Bacillariophyta or diatoms (13%) and Chrysophyta (2%).

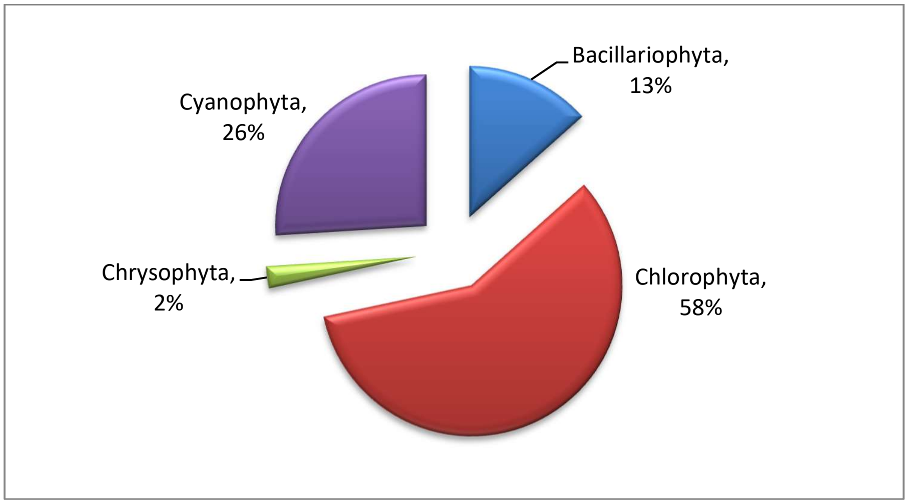


Figure 72 - Relative abundance of phytoplankton major groups

The phytoplankton present with their distribution and diversity is shown in *Table 53***.** The diatoms, blue-green alage and green algae are widely distributed in all six sampling stations. Diatoms are used as biological indicators because of their ubiquity, short generation time, broad range of tolerance against contaminants, ease of use, and well-documented taxonomy (Kireta et al. 2012; Mendes et al. 2012). Cyanophyta or blue-green algae are known to be tolerant of pollution because of their ability to utilize high nutrient levels, and have been known to tolerate high levels of stress in aquatic environments (Palmer, 1969).

A total of 123,348 phytoplankton organisms were present in the six sampling stations. The green algae *Spirogyra, Zygnema*, and *Mougeotia*, were the most abundant with cell density of 27284 cells/m^3, 18267 cells/m^3 and 17280 cells/m^3, respectively. High cell density was also exhibited by the blue-greean algae *Oscillatoria* with 17981 cells/m^3.

Table 53 - Composition, distribution and abundance of phytoplankton in Candelaria, Zambales (June, 2018)

TAXA	*Station 1*	*Station 2*	*Station 3*	*Station 4*	*Station 5*	*Station 6*
Phylum Bacillariophyta	**3092**	**1117**	**546**	**182**	**2365**	**9224**
Fragilaria	857	182	208	0	494	1533
Navicula	1013	494	130	0	468	2183
Nitzscia	442	130	0	182	598	3248
Surirella	546	104	156	0	442	546
Synedra	234	208	52	0	364	1715
Phylum Chlorophyta	**26608**	**7873**	**1273**	**520**	**8367**	**27232**

TAXA	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Mougeotia	7899	3924	832	416	1195	3014
Oedogonium	2572	1845	234	0	442	2183
Spirogyra	14187	0	0	0	1325	11771
Staurastrum	364	0	78	0	182	780
Tetraedron	0	0	130	104	0	130
Zygnema	1585	2105	0	0	5223	9354
Phylum Chrysophyta	**961**	**0**	**0**	**286**	**572**	**1065**
Dinobryon	961	0	0	286	572	1065
Phylum Cyanophyta	**7743**	**4106**	**2027**	**3352**	**5041**	**9796**
Calothrix	624	0	0	754	416	1377
Lyngbya	6548	0	0	1091	0	2209
Oscillatoria	572	4106	2027	1507	3560	6210
Spirulina	0	0	0	0	1065	0
DIVERSITY INDEX	***Station 1***	***Station 2***	***Station 3***	***Station 4***	***Station 5***	***Station 6***
Taxa Richness	14	9	9	7	14	15
Total Individuals	38404	13098	3847	4340	16346	47318
Dominance_D	0.2168	0.2357	0.3355	0.2298	0.1727	0.1375
Simpson_1-D	0.7832	0.7643	0.6645	0.7702	0.8273	0.8625
Shannon_H	1.897	1.628	1.493	1.645	2.139	2.274
Evenness_e^H/S	0.4762	0.5658	0.4945	0.74	0.6063	0.6481

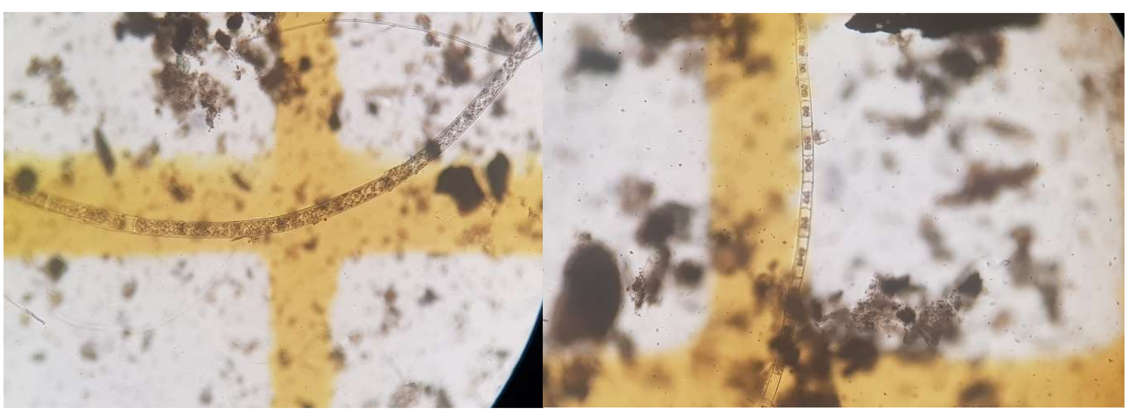


Plate 23 - Some phytoplankton observed (left) Spirogyra, (right) Zygnema

The computed species index of diversity (H') for the phytoplankton community ranged from 1.49 to 2.27, while the evenness index is 0.47 to 0.74. These values are relatively low and are indicative of a disturbed environment.

Palmer's pollution index was also calculated for the sampling stations, and it showed a score of 13. The presence of pollution tolerant phytoplankton such as *Oscillatoria, Synedra, Navicula*, and *Nitzschia* may suggest that organic pollution is present in the surveyed sites. Potentially toxic phytoplankton *Lyngbya sp.* was also recorded. The population of these potentially harmful organisms will be included in the monitoring program of freshwater ecology.

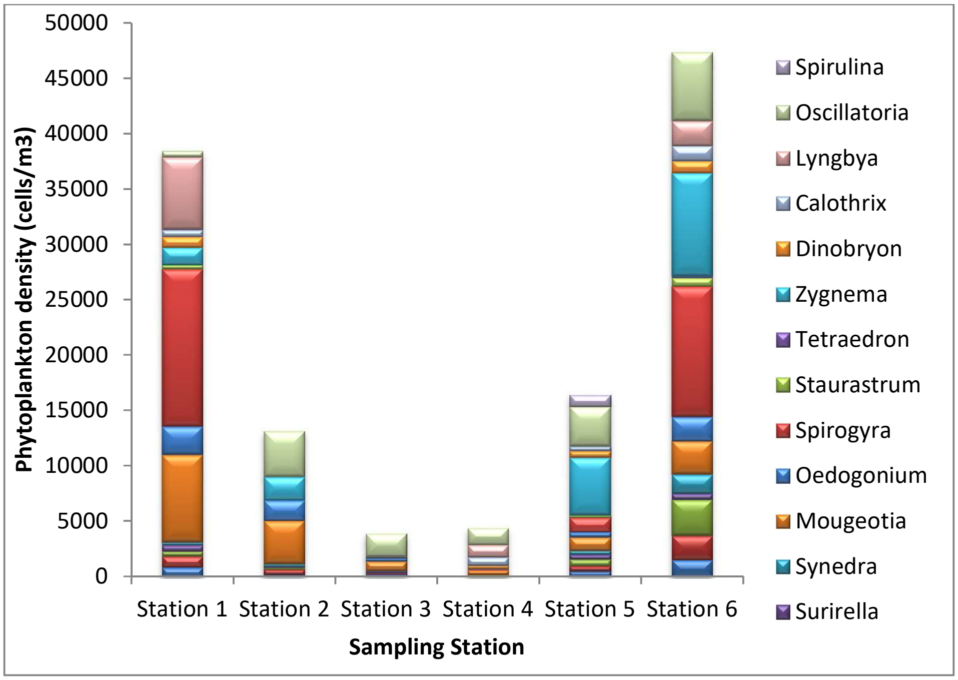


Figure 73 - Phytoplankton density across 6 sampling stations

2.2.3.3.2.3 Zooplankton

Analysis of samples taken from the six sampling stations showed a total of 4 major zooplankton groups (*Figure 74*) A total of 8 taxa were encountered. Arthropoda comprised of copepods and cladocerans dominated the water bodies surveyed. These arthropods made up 50% of the total zooplankton population, while Annelida (polychaete larva) 25%. Relatively low abundance was exhibited by Rotifera and Mollusca with 17% and 8%, respectively.

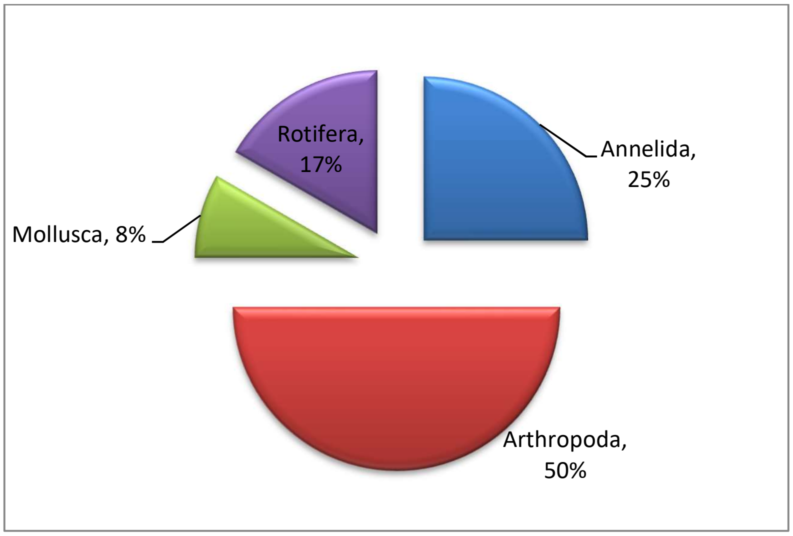


Figure 74 - Relative abundance of zooplankton major groups

Generally, the zooplankton are sparse in terms of number of individuals and taxa richness. In terms of abundance, calanoid copepodite (larva) and polychaete larva were the most abundant which comprised of 156 indv/m^3 . The zooplankton taxa present, their distribution and diversity were recorded in *Table 54*. Results showed relatively low density ranging from 52 individuals/m^3 to 156 individuals/m^3. Diversity indices indicate that zooplankton communities in the area during the sampling period were low. This may be indicative of the stressful environment in the habitat of zooplankton communities.

Table 54 - Composition, distribution and abundance of zooplankton in Candelaria, Zambales (June, 2018)

TAXA	*Station 1*	*Station 2*	*Station 3*	*Station 4*	*Station 5*	*Station 6*
Phylum Annelida	52	0	0	0	0	104
Polychaete larva	52	0	0	0	0	104
Phylum Arthropoda	0	0	0	52	0	0
Isopoda	0	0	0	52	0	0
Order Cladocera	0	0	52	0	0	0
Bosmina	0	0	52	0	0	0
Order Copepoda	0	0	156	52	0	0
Calanoid copepodite	0	0	156	0	0	0
nauplius larva	0	0	0	52	0	0
Phylum Mollusca	0	0	52	0	0	0
Bivalve larva	0	0	52	0	0	0
Phylum Rotifera	52	0	52	0	0	0
Gastropus	52	0	0	0	0	0

TAXA	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Lecane	0	0	52	0	0	0
DIVERSITY INDEX	***Station 1***	***Station 2***	***Station 3***	***Station 4***	***Station 5***	***Station 6***
Taxa Richness	2	0	4	2	0	1
Total Individuals	104		312	104		104
Dominance_D	0.5		0.3333	0.5		1
Simpson_1-D	0.5		0.6667	0.5		0
Shannon_H	0.6931		1.242	0.6931		0
Evenness_e^H/S	1		0.866	1		1

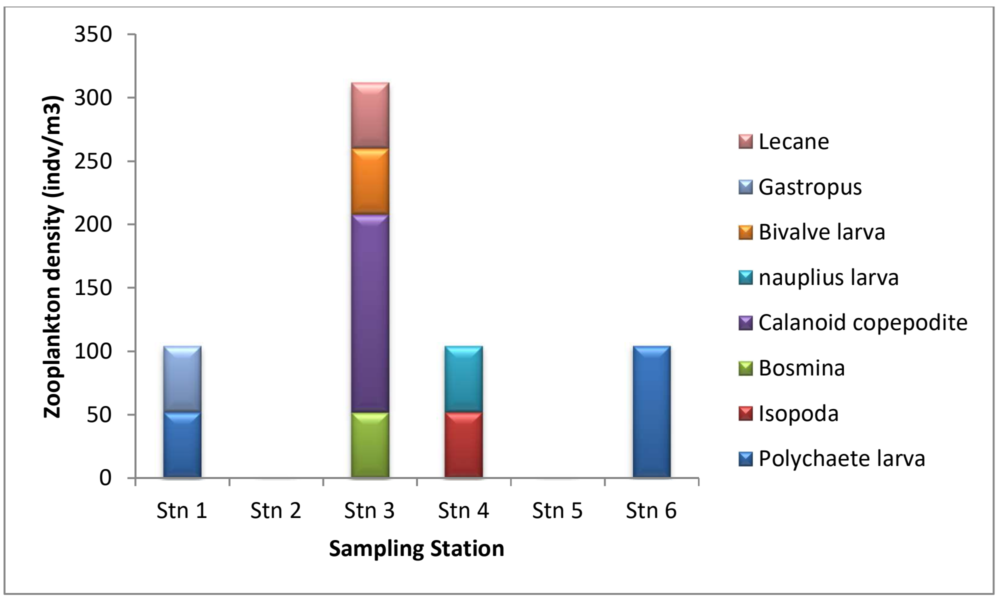


Figure 75. Zooplankton density across 6 sampling stations

2.2.3.3.2.4 Fish and other fauna

Fish study was conducted through chance interviews of residents and literature search. Freshwater fish species and other aquatic fauna recorded in the proposed site are listed in *Table 55*.

Table 55 - Freshwater fish and other aquatic fauna in Candelaria, Zambales (June 2018)

Fish species present	Conservation status
*Oreochromis niloticus (*Nile Tilapia)	
Anguilla sp. (Freshwater eel)	Near threatened
Clarias sp. (Catfish)	Least concern
Ophiocephalus sp. (Mudfish)	Least concern
*Glossogobius aureus (*Biya)	Least concern
Other aquatic fauna	
Shrimps	
Clams	

The freshwater fish species present were common and widespread forms which are well adapted to tropical freshwater systems. However, the freshwater eel *Anguilla sp.* is categorized as Near Threatened by the IUCN Red List of Threatened species. The population dynamics of this fish taxon will be closely monitored in future freshwater monitoring programs.

2.2.3.4 Impact Assessment

Activities such as earth moving and vegetation removal within the development area will potentially impact the river systems. Loss of canopy cover, siltation and sediment runoff may be a source of threat to existence of locally important species, such as freshwater eel *Anguilla sp.*. Appropriate erosion control measures will be implemented particularly during high precipitation periods.

Freshwater ecosystem monitoring will be conducted congruently to assess the population dynamics of near threatened species.

Channels or dams that may be built in the river systems may have potential impact to loss of freshwater habitat. Freshwater ecology monitoring will be conducted regularly within the project sites.

2.2.4 Marine Ecology

2.2.4.1 Marine ecology baseline assessment - Objectives

Marine ecology baseline assessment was conducted by a team of fishery and marine biologists on 06 to 08 June 2018 in the nearshore areas covering five coastal Barangays in the coastline of Candelaria, downstream of the proposed nickel mining project in Candelaria, Zambales. This report presents the findings of the assessment which covered essential coastal habitats and fisheries resources in the primary coastal impact area of the project and contiguous environs.

Coastal habitats and the ecological functions that they sustain, nurture many goods and services that are biologically and economically important for marine biodiversity, sustained fisheries production and aesthetic values. The objective of the assessment is to account and describe the condition of primary benthic habitats, if present in significant quantity, its associated fisheries resources, resource use practices and ecological functions that can be potentially susceptible to disturbances emanating from the establishment of the project or be subjected to stresses associated with potential anthropogenic environmental impacts attributable to the Project's operation. The baseline data set generated from the survey of the subject coastal area and contiguous environs will subsequently be used as input to the overall Environmental Impact Assessment for the proposed project. Ultimately, the baseline profile will serve as the principal tool 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 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 areas 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 defined for future monitoring purposes.

2.2.4.2 The Coastal Impact Area

Candelaria is a third class municipality nestled at the foot of the Zambales Mountain Range in the east, lying along the coast of the South China Sea in the west and bounded by the municipalities of Sta. Cruz on the north and Masinloc to the south. It is the fourth largest town in terms of land area in the entire province of Zambales (*Figure 76*).

The municipality is politically subdivided into 16 barangays including the Poblacion proper. There are eight (8) coastal barangays namely Binabalian, Libertador, Malimanga, Sinabacan, Dampay, Malabon, Panayunan and Uacon.

The coastal impact area lies about 4 kilometers downstream of the proposed mine site facing the South China Sea. The shelf is shallow and deep indentions with depths ranging from 22 to 29 meters characterize most portions of the sea. The coastal area is flanked by the estuaries of three major river systems – the Uacon River, San Vicente River, both in the jurisdiction of Candelaria, and the Lauis River in the boundary of Candelaria and Masinloc. Uacon Lake is found east of Barangay Uacon while small wetlands are also found inside the San Vicente River (*Figure 77*;

Plate 24

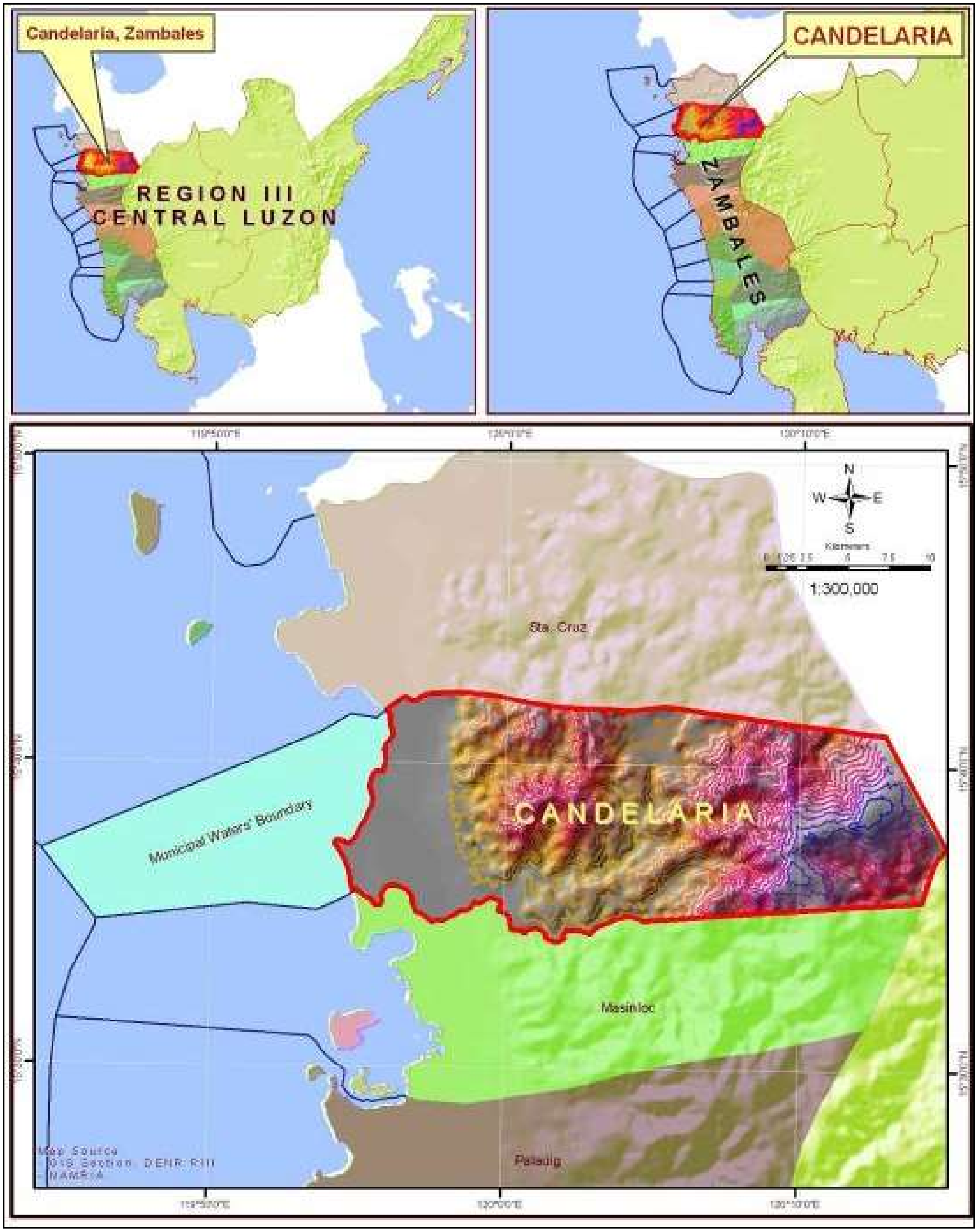


Figure 76 - Candelaria Municipality and its municipal waters (map sourced from Candelaria Integrated Coastal Resource Management Plan, 2011

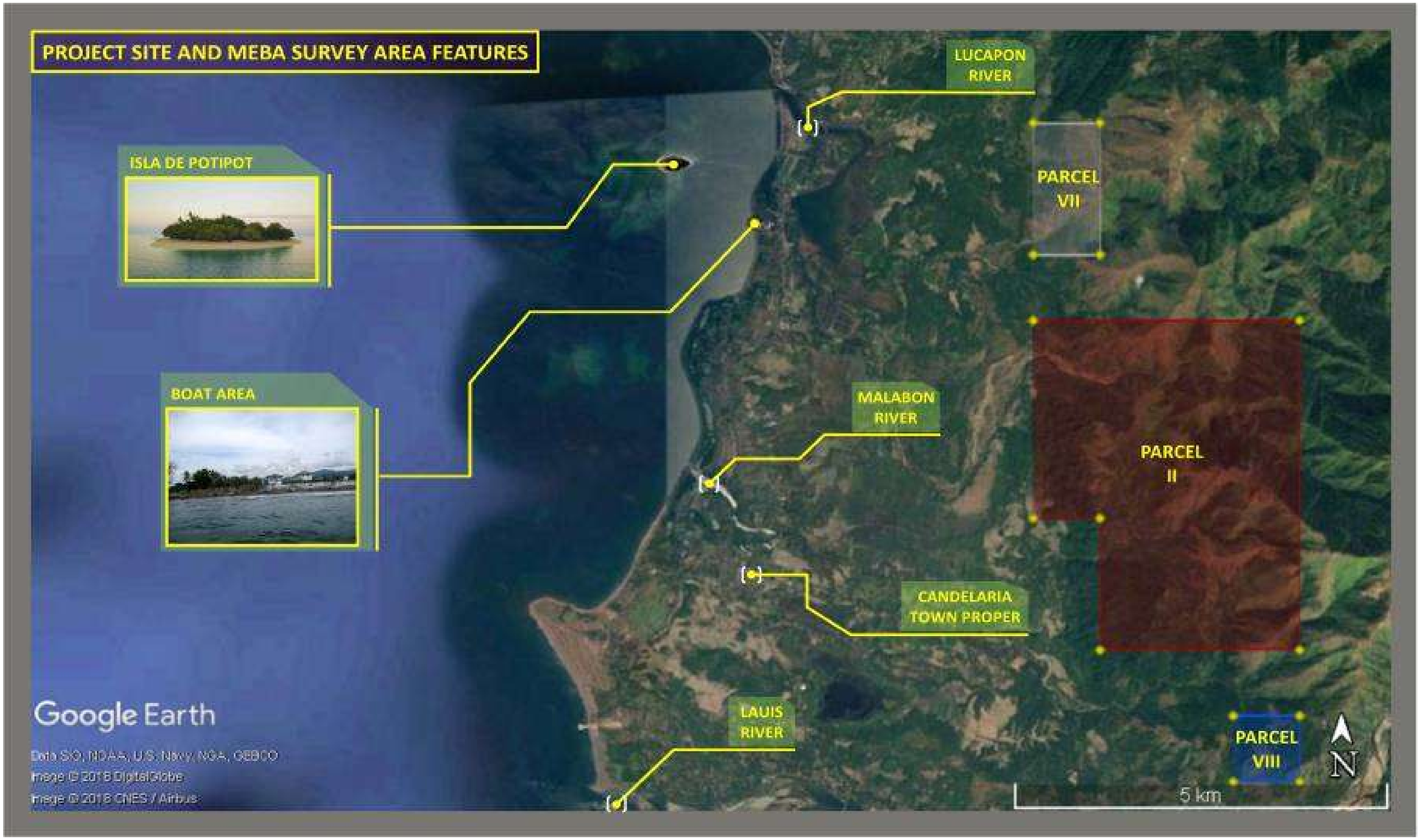


Figure 77 - Map showing the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales (map prepared by Jose Rene Villegas)

These water bodies are fed by the hinterlands of the Zambales mountain range and are oftentimes laden with sediments and organic material coming from denuded portions of the mountain and from small-scale mining activities that extract magnetite, black sand, and chromium, among others. In view of this, shallow nearshore waters in approximately 10 kilometers of coastline straddling the five coastal Barangays are heavily silted. Patches of corals exist in the nearshore area, in widely dispersed distribution mostly in reef flats that are already heavily degraded and overcome by sediments and algal growth (*Figure 78*).

The major groups of coral colonies with relatively better live coral profiles occur in two marine protected areas (MPA) - the Sinabacan - Malimanga Marine Protected Area and the Batong Lakay MPA (*Figure 79*). These MPAs, as well as the few patches if intermittently occurring coral reefs have been previously subjected to intense blast fishing and fishing with the use of cyanide to catch live fish. Mangroves are absent in the coastline but are found lining up the rivers and in the swampland of Uacon Lake. The mangroves lining up the riverbanks are comprised of thin strips, as cultivated fields, human settlements and some fishponds already occupy the inner flanks. Potipot Island, in front of Barangay Uacon, is a popular destination for local tourists.

The ecological degradation brought about by the use of destructive fishing gears, including fine mesh nets and trawls that appear to have caused recruitment overfishing is vividly perceived in the small sizes of juvenile fish being unloaded and sold in street markets. During the 3-day survey, hardly any significant fishing operation was observed as most fishing boats operate way out into the South China Sea in order to have a viable catch.

In 2011, the Municipality of Candelaria formulated and adopted an Integrated Coastal Resource Management Plan (ICRMP) through the initiative of the Integrated Coastal Resource Management Project (ICRMP) that was implemented by the Department of Environment and Natural Resources (DENR) with the collaboration of the Bureau of Fisheries and Aquatic Resources, with funding assistance from the Asian Development Bank (ADB) and the Global Environment Facility (GEF).

Plate 24 - Coastal waters in Candelaria, Zambales with project site in the background (left), and Uacon Lake (right).

Map Showing The Reef and Mangrove Areas of Candelaria, Province of Zambales

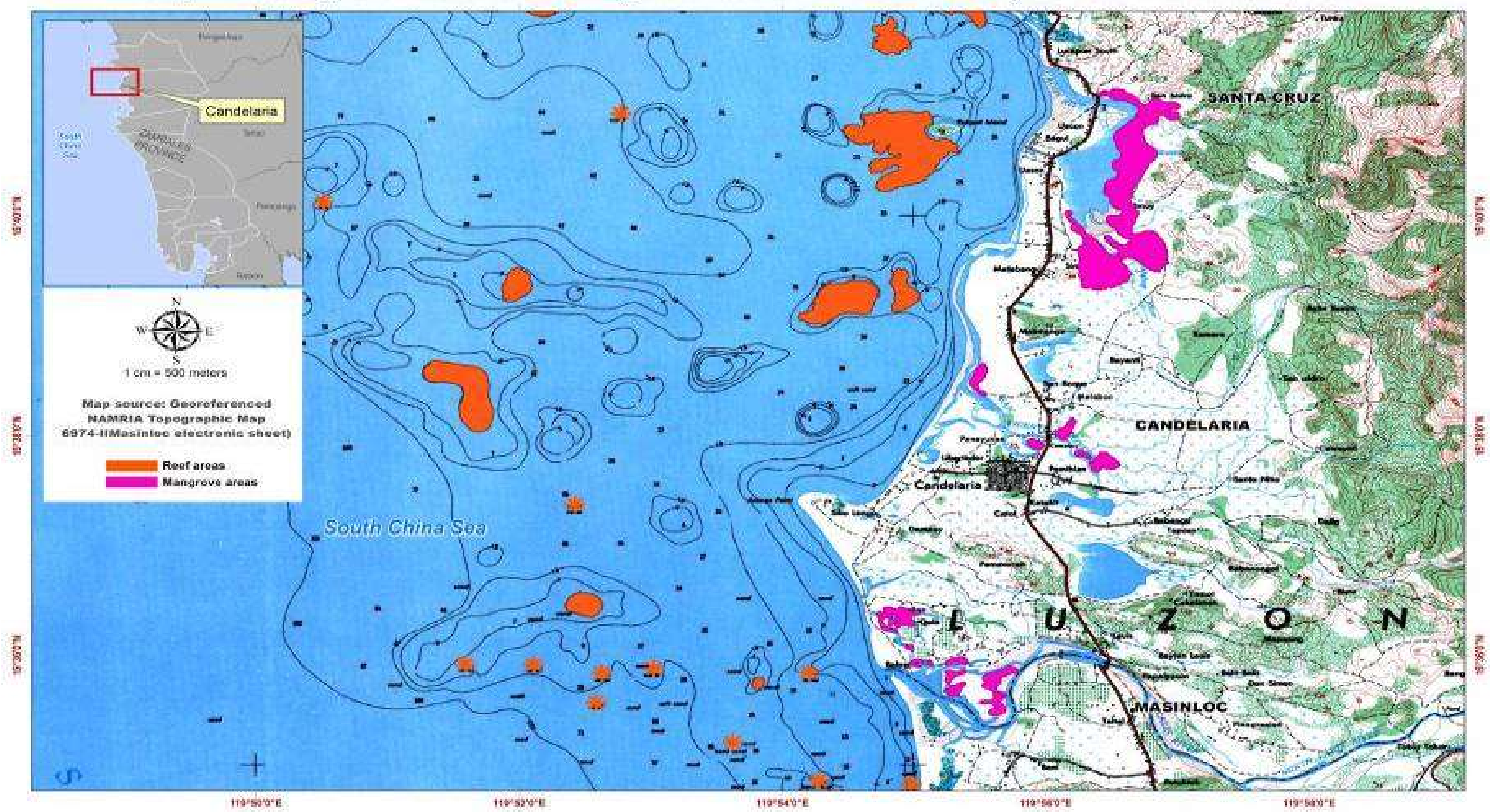


Figure 78 - Coastal habitat map showing patches of dispersed coral colonies and mangroves in Uacon Lake in the project's impact area in Candelaria, Zambales (Map prepared by Lawrence Aporto; reference: NAMRIA).

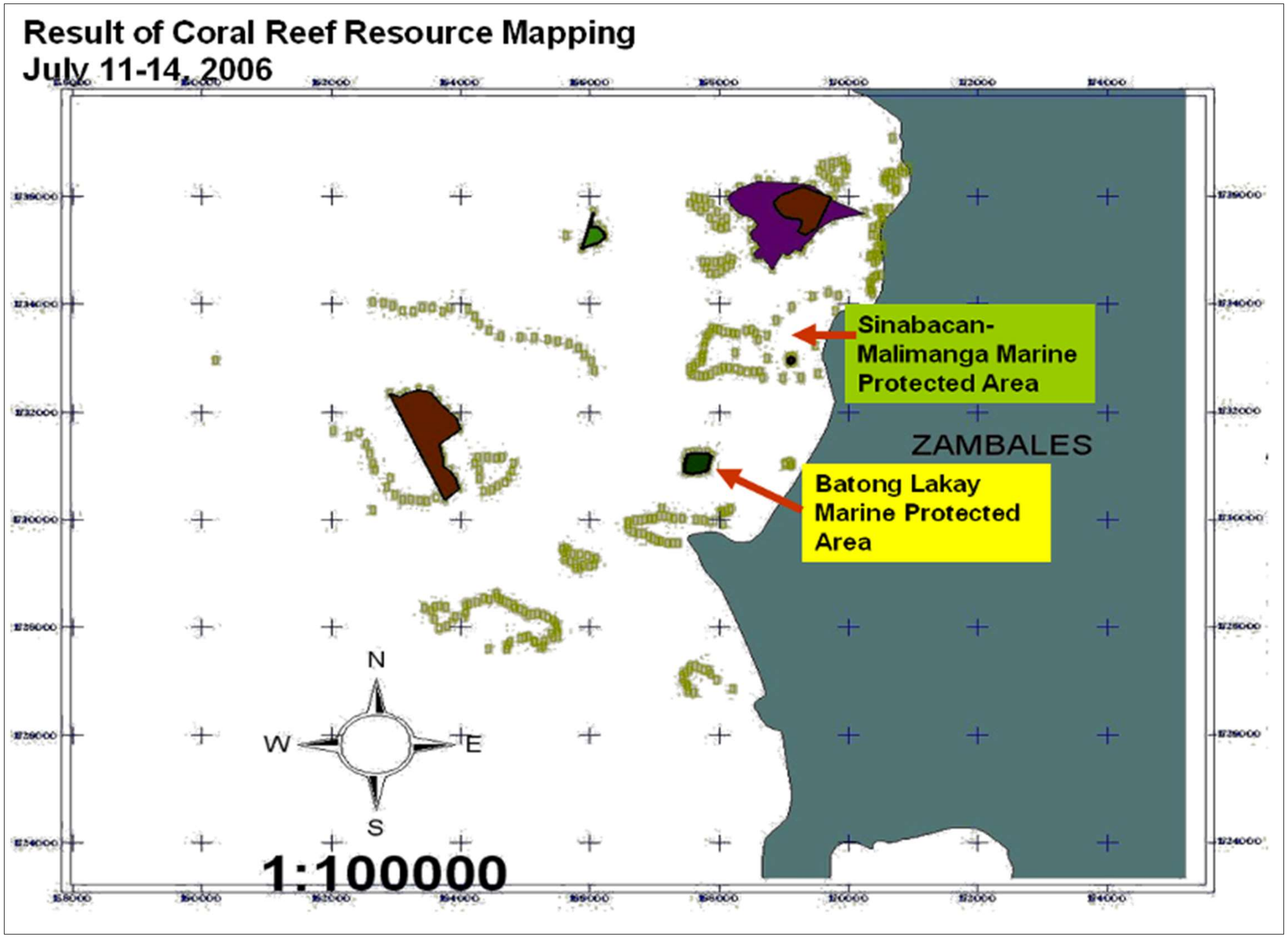


Figure 79 - Marine Protected Areas in coastal waters of Candelaria, Zambales

2.2.4.3 Scope of Assessment

The survey and profiling covered a linear stretch of coastal waters estimated to be more than 10 km in length following reef contour where they are present. The discussion of survey results, as well an overview on the current state of the fisheries sector in the study area, are presented in the next sections.

Any potential impacts emanating from the proposed nickel mining project, especially during construction of its facilities and extraction of nickel ores will inevitably affect the coastal area, its habitats and benthic communities through the three river systems that may carry sediments and other mine debris. In spite of the great distance of the coastal area from the proposed nickel mine site, the assessment required a full accounting of important benthic habitats and associated ecological structures within the survey pathways and stations covering a distance of almost 6 kilometers from northeast to southwest. Detailed coral assessments were conducted inside the two MPAs while mangrove surveys were undertaken in Uacon Lake and inside the Malabon River. Documentation of yields from actual fishing operations were undertaken to support fisheries information from key informants. Initial information generated from key informants conveyed the absence of seagrass beds but the survey team encountered seagrass resources on the southern side of Potipot Island.

The scope of work of the coastal/marine survey focused on the conduct of the following activities:

- Verification and, if present in significant quantity, determination of distribution and composition and coral cover and associated benthic life forms supported by analysis of present conditions of the coral reefs and the factors that lead to coral mortality;

- Definition of species composition, abundance and diversity of reef-associated fish communities;

- Identification of commercially-important macro invertebrates in the survey stations;

- Determination of species, composition, density, and diversity of seagrass resources and associated macro benthic algae where such resources occured;

- Assessment of species composition and present condition of mangrove stands within the study area;

- Catalogue presence of important macro-invertebrates and macrobenthos communities in specific study stations;

- Rapid assessment of species composition and catch rates of primary target species of fish, type of fishing gears employed in the area, and the documentation of actual fishing operations to validate dominant species of fish in front of the project site.

- Assessment of plankton community structure, including HAB-causing phytoplankton.

The survey data represents a fairly reasonable baseline data set that portrays the condition of coastal habitats in a "without the project" scenario generated through standard scientific assessment protocols. The resulting environmental profile generated from the assessment is aimed at scientifically illustrating the current condition of ecological niches in representative portions of the coastal environment which can subsequently serve as a benchmark reference for comparing the state of the coastal environment when the project is already in operation. More importantly, the characterization of susceptible end-points and critical benthic habitats, and identification of causes and pathways that carry stressors will provide valuable data from where objective mitigating measures can be drawn. The adoption of mitigating measures for long-term application are deemed as the most suitable strategic initiatives to maintain ecological structures and functions in their pre-project condition, or to be improved to acceptable thresholds over time. The investigation of a broad swath of coastal area, in this case more than 10 kilometers long of a swath of coastal waters and benthic substrates, can serve as a modest basis for enabling comparison of the baseline data set against survey information obtained in future, if the same sampling stations are monitored and the same methods are utilized.

2.2.4.4 Assessment Methods and Survey Stations

The survey methods employed follow standard coastal resource survey techniques prescribed by English *et. al.* (1997), modified in accordance with *in-situ* conditions following rapid appraisal techniques for coastal resources. Survey results portray a general view of the types and current condition of the coastal environment and the marine resources present in the area at the time of sampling and cannot represent an irreversible situation.

The survey methods and stations are the following:

2.2.4.4.1 *Conduct of manta tow survey for corals and general profiling of the benthic environment*

Manta tow surveys (*Plate 25*) were conducted in continuous stations in order to determine benthic profile of the seabed, identify and quantify corals where they occur along the tow pathways, pinpoint location of seagrass beds and determine presence of aggregates of demersal fish, if any, over a broad stretch of the coastal zone both inside and outside of the impact area. In particular, 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 coral reefs at specific intervals over a long stretch of coastal area, allowing a collective picture of the resources in the impact area. 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 collective picture generated can show a fairly accurate description of the state of the coastal area under study. In areas where significant coral reefs occur, results from a manta tow survey are used to pinpoint location of specific stations where more detailed underwater coral characterization employing line transects will be undertaken. Manta tow surveys are also used to identify areas where macro-invertebrate surveys can be undertaken.

Plate 25 - Manta tow being undertaken in continuous pathways (left) and part of the reef observed in one of the tows (right).

A total of forty-seven (47) manta tow stations were surveyed during the marine ecology baseline assessment in Candelaria, covering a linear distance of 10.7 kilometers following the coastline of Barangays Uacon to Dampay (*Figure 80*). The coordinates of the manta tow stations are presented in *Table 63*.

2.2.4.4.2 Line Intercept Transect (LIT) method for detailed coral reef assessment

In coral reefs where significant live corals occur as compared to other stations surveyed in the manta tows such as in the marine protected areas, transect lines are laid out in order to more precisely estimate the relative abundance of living and non-living things on the sea bottom observed within the transect area. The survey protocol calls for the laying out of 50-m transects parallel to the shoreline and following the reef contour (*Plate 26*). Data generated from line-intercept method for coral reef assessment provides more rigid data sets on relative percentage of live coral cover as well as coral species distribution that can be ultimately used for comparative evaluation if the same survey stations are monitored in the future, under the Project's environmental monitoring plan. The method used and categories utilized for classifying coral cover follow standard ratings used for live coral distribution (*English et. al, 1997 and Gomez, et. al., 1981*).

The LIT station coordinates are presented in *Table 56* and depicted in *Figure 81.*

Table 56 - Coordinates of LIT stations surveyed for coral cover distribution during the marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-08 May 2018.

WP Code	LATITUDE	LONGITUDE	REMARKS
LIT1	N 15.650878°	E 119.916126°	Transect line laid out in the reef slope of the Batong Lakay MPA in Bgy. Sinabacan, more than 300 meters from the shoreline. Results of LIT survey revealed an average live coral cover of 50.4% (Good); Depth 4-6 meters
LIT2	N 15.662158°	E 119.923407°	Transect laid out inside the Sinabacan-Malimanga MPA in reef crest with densest coral cover. Results of LIT survey revealed an average live hard coral cover of 36.6% (Fair). Dead Corals with algae was seen to be dominant at 45.8% and rubble at 12.6% of the surveyed area; Depth 5-7m
LIT3	N 15.680567°	E 119.932866°	The station was located in a degraded reef flat in Bgy. Uacon across Puerto del Mar Resort. Manta tow survey discerned little live corals amidst DCA. LIT results point to an average live coral cover of 2.8% (Poor); Dead Corals with Algae at 93.0%. Depth 4-5m

Plate 26 - Underwater survey with scuba using line intercept method and line transect laid out in found within Batong Lakay and Sinabacan-Malimanga MPAs; and across Puerto del Mar Resort in Barangay Uacon, Candelaria, Zambales Province; June 06-07, 2018.

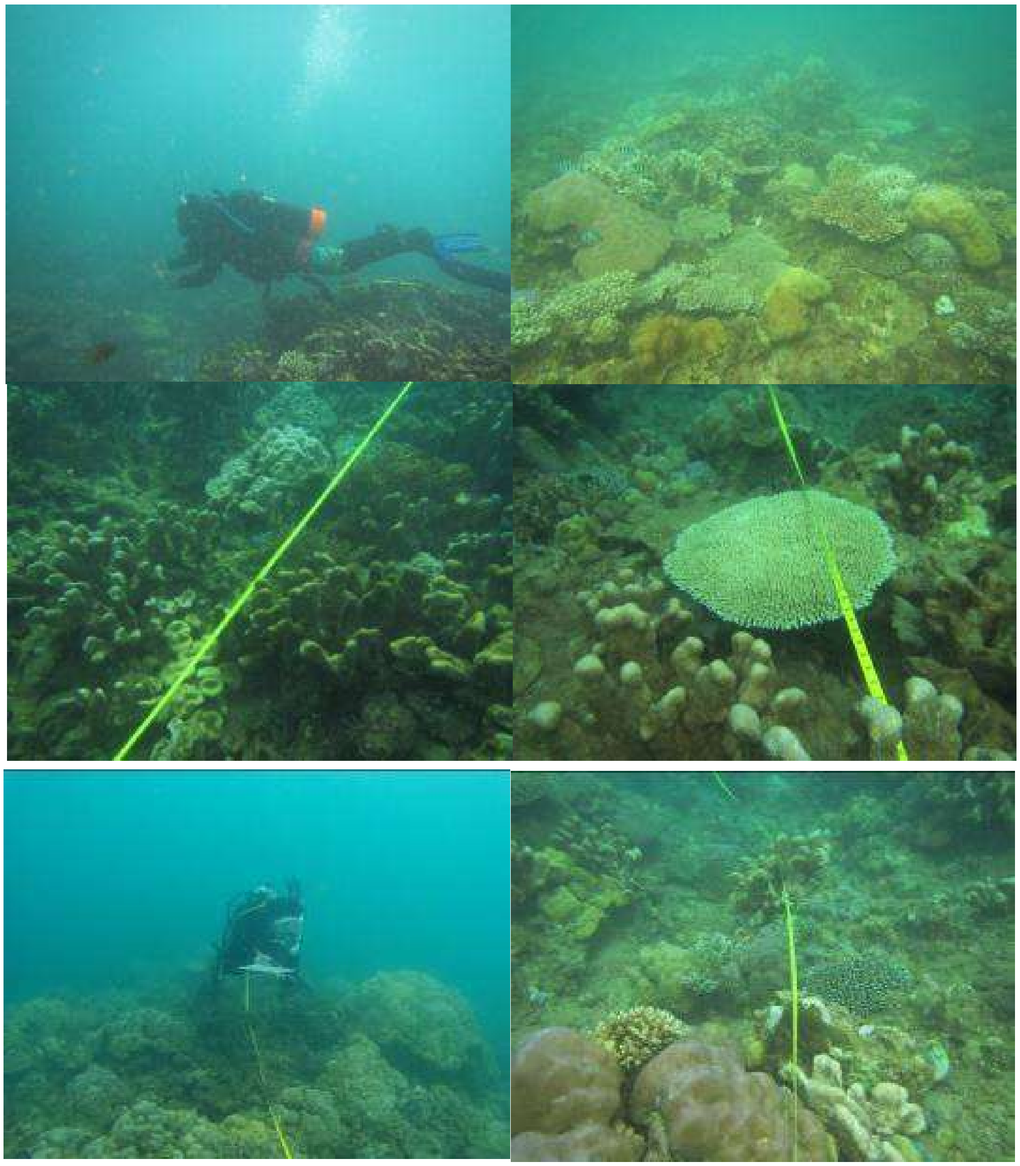


Figure 80 - Manta tow stations surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

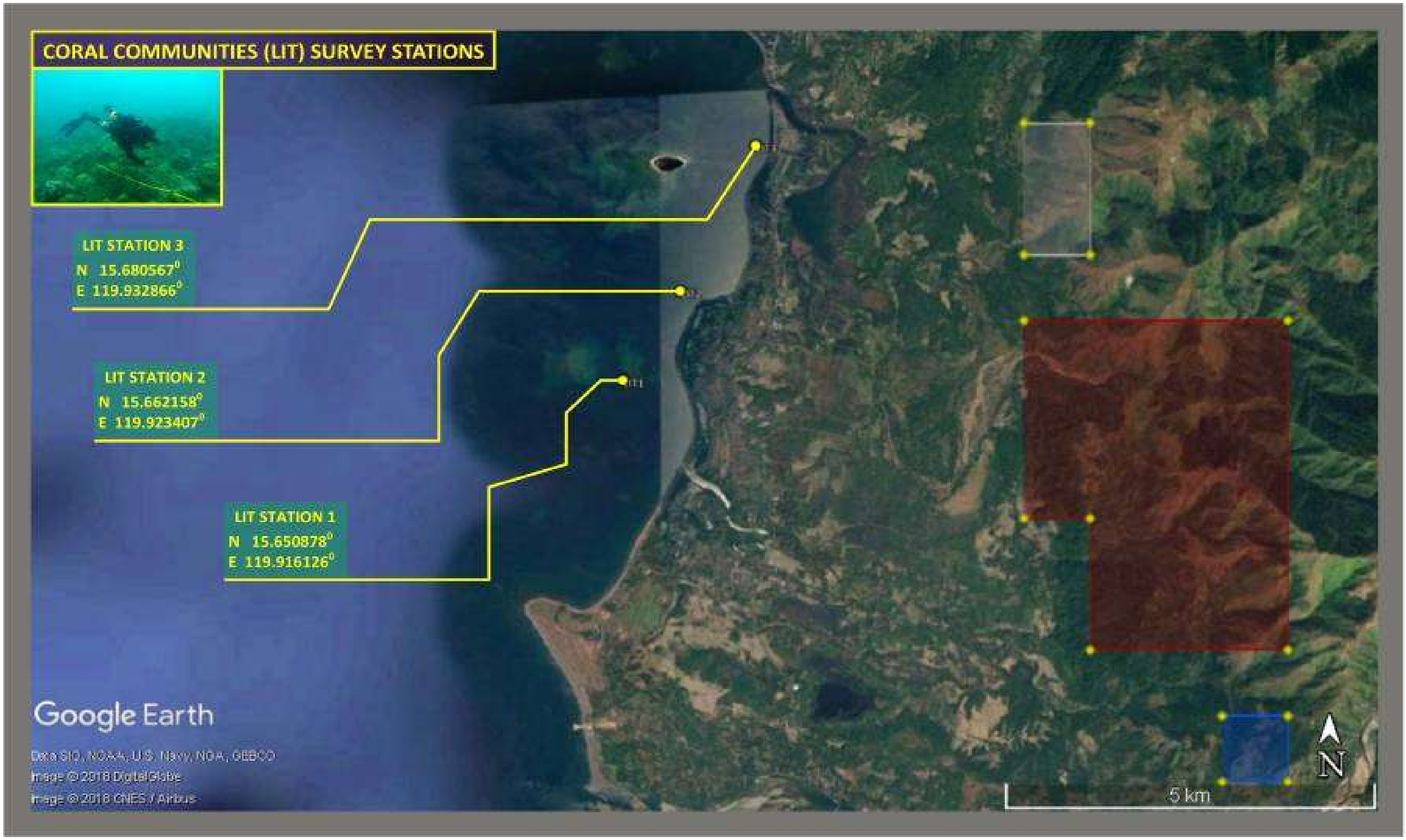


Figure 81 - Location of Line Intercept Transect stations surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

2.2.4.4.3 Spot Dives

Spot dives employing scuba were undertaken to verify presence or absence of corals in manta tow stations that indicated presence of corals that needed closer validation. Two (2) strategic points were verified – one spot dive south of the Batong Lakay MPA and the other in a reef flat east of Potipot Island. The spot dive stations are presented in *Table 59* below and depicted in *Figure 82*.

Table 57 - Coordinates of spot dives for substrate and coral cover verification during the marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-08 May 2018.

WP Code	LATITUDE	LONGITUDE	REMARKS
SPD1	N 15.639748°	E 119.891780°	Located in a coral patch southeast of the Batong Lakay MPA. Dive indicated: Live Hard Coral=40%, Soft Coral=0%, Dead Coral=0%, Dead Coral w Algae=30%, Coral Rubble=20%, Sand/Silt=10%; Depth at 4.7m extended portion of Batong Lakay Reef.
SPD2	N 15.684150°	E 119.924734°	Part of a short fringing reef bordering Potipot Island in the eastern coast. The spot dive revealed Live Hard Coral=15%, Soft Coral=0%, Dead Coral=0%, Dead Coral w Algae=40%, Coral Rubble=30%, Sand/Silt=15%; Depth at 7.7m proximal to Isla de Potipot

2.2.4.4.4 Assessment of reef-associated fish assemblages employing Fish Visual Census (FVC)

The line intercept stations are subsequently used to account for fish communities associated with coral reefs, shelters or other benthic habitats through standard fish visual census (FVC) prescribed in *Survey Manual for Tropical Marine Resources* (*English et. al, 1997*). The conduct of FVC is designed to document a fairly accurate picture of demersal fish species richness, abundance and biomass of fish assemblages associated with benthic habitats (Plate 3 previous page). In this case high values for these principal variables can indicate the overall ecological condition of a reef area and productivity and diversity of demersal fisheries. For instance, a square kilometer of healthy reef can host as much as 2000 species of fish and support a fisheries production of up to 20 MT per year (*White, Alan; DENR Coastal Resource Management Project*). 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.

The coordinates of the FVC stations are listed in *Table 58*; the locations are shown in a map in *Figure 83.*

Table 58 - Coordinates of FVC stations surveyed for fish species richness, abundance and biomass employing the FVC method during the marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-08 May 2018.

WP Code	LATITUDE	LONGITUDE	REMARKS
FVC1	N 15.650878°	E 119.916126°	Same location as LIT1 with a depth of 6-15m. Recorded 365 individuals within a 500m2 transect area with 42 species distributed in 13 family taxa. Most abundant were *Amblyglyphidodon curacao* (60 individuals) followed by *Pterocaesio tessellata* and *Abudefduf sexfasciatus* having 30 individuals each.
FVC2	N 15.662158°	E 119.923407°	Same location as LIT2 with a depth of 6-15m. Recorded 59 individuals within a 500m2 transect area with 14 species distributed in 9 family taxa. Most abundant were *Amblyglyphidodon leucogaster* (15 individuals) followed by *Acanthurus nigricans* and *Scarus ghobban* having 10 individuals each.
FVC3	N 15.680567°	E 119.932866°	Same location as LIT3 with a depth of 6-15m. Recorded 64 individuals within a 500m2 transect area with 14 species distributed in 9 family taxa. Most abundant were *Chlorurus bleekeri* (15 individuals) followed by *Acanthurus lineatus* and *Scarus niger* having 8 individuals each.

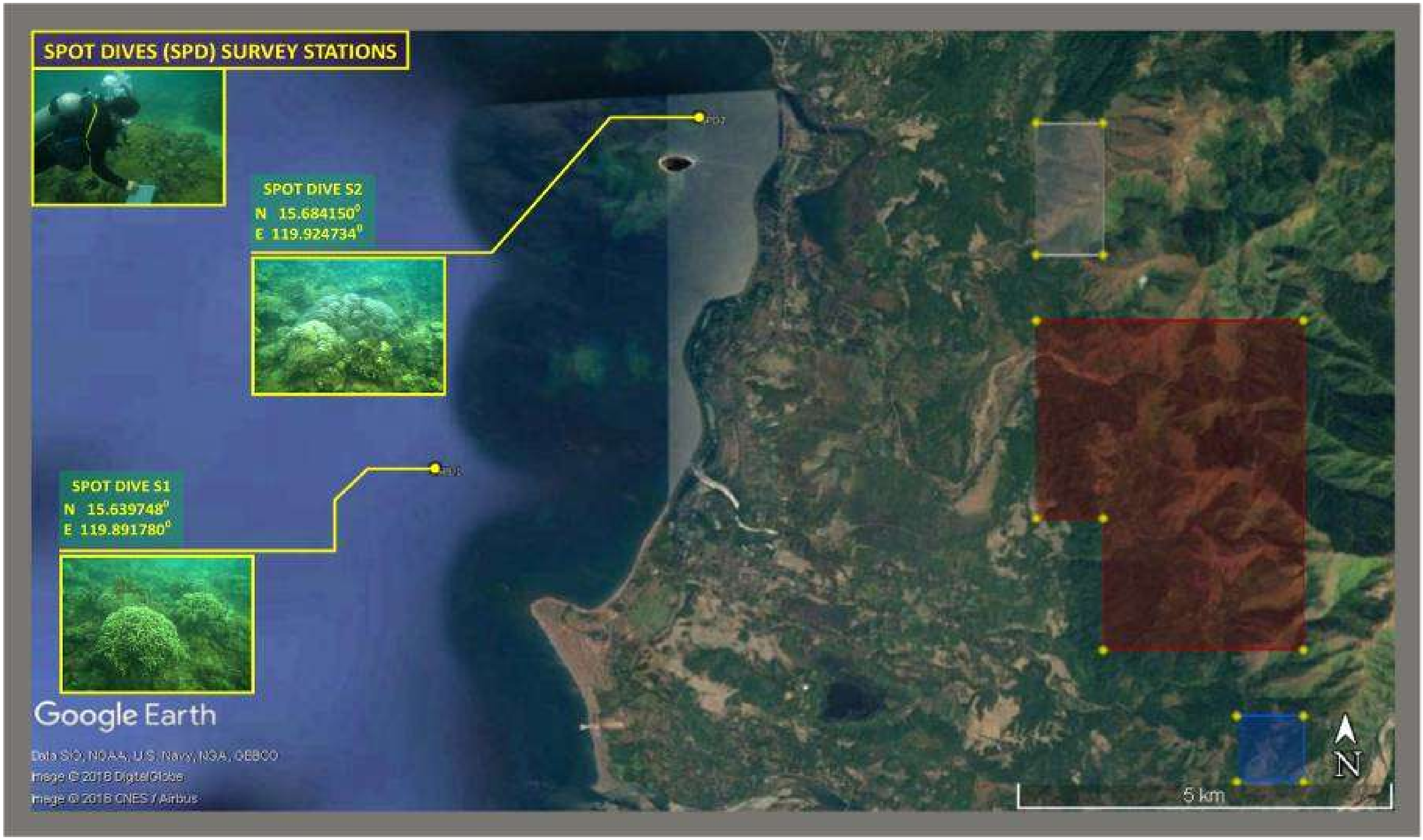


Figure 82 - Location of spot dive stations surveyed to validate coral cover and other benthic life forms during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jo se Rene Villegas).

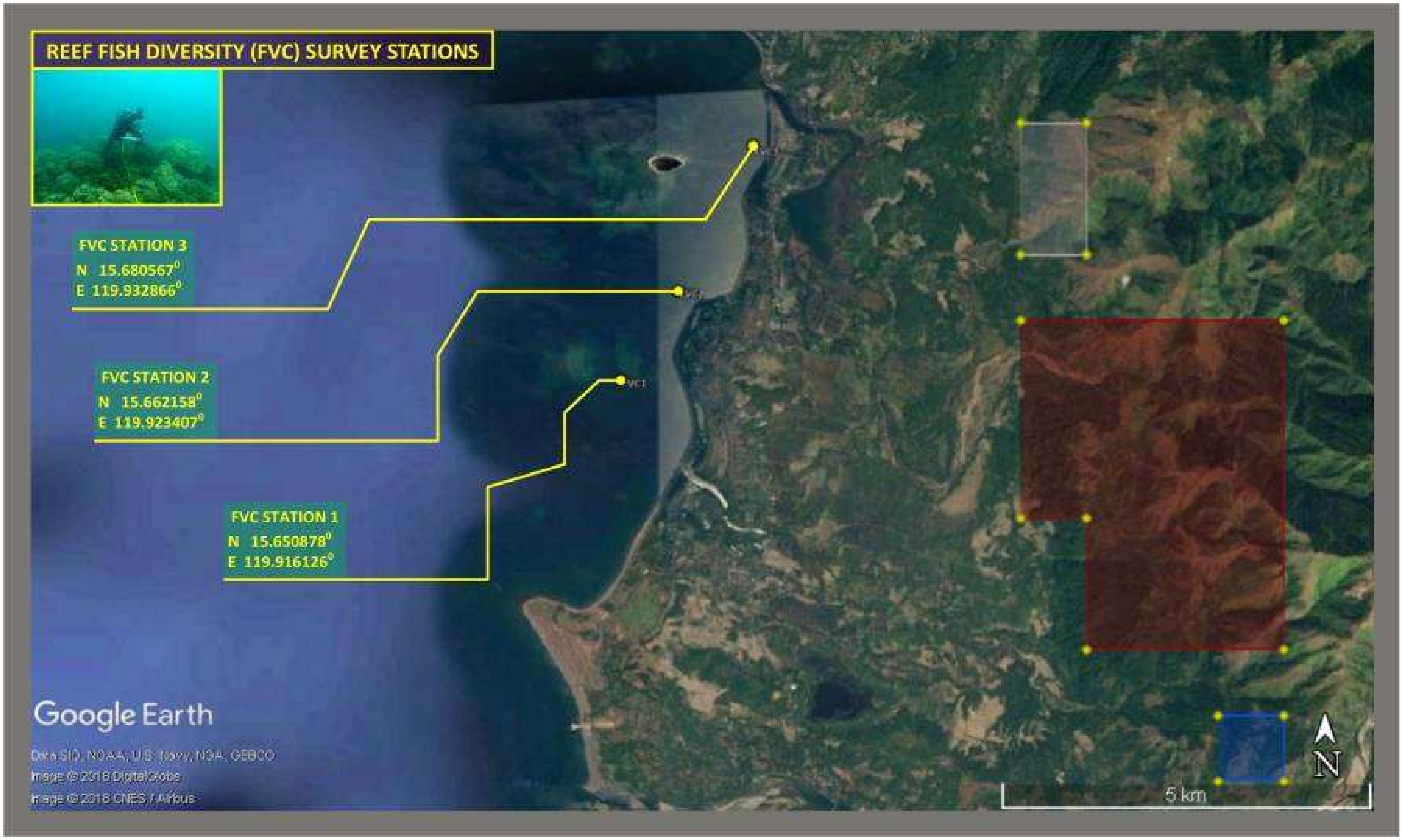


Figure 83 - Location of fish visual census stations for recording of fish species richness and abundance during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

2.2.4.4.5 Assessment of seagrasses and associated macro-algae

Where they occurred, seagrass communities were surveyed following principles of the Saito-Atobe Quadrat-Transect method technique described by English et al. (1997). Since the seagrass meadow is narrow and sparse, only one transect was accommodated located in a shallow coastal shelf southeast of Potipot Island. The station coordinates are: N 15.679570°/E 119.919669° (start of transect) and N 15.679882°/E 119.919342 (end of transect). The ransect was laid parallel to the shore starting from the edge of the seagrass bed closest to shore. Seagrass species were then identified and their canopy cover visually estimated within two 0.25 m2 stainless steel quadrats haphazardly placed at the left and right of the transect line, at 5 m intervals starting from 0 meter. The substratum features within the quadrats were also noted and their coverage estimated. Initial determination of sites for the seagrass transects were undertaken through key informants and through spot dives as well as manta tows. During key informant interviews, fishers alleged that there were no longer seagrass beds occurring in the project impact area. Extensive manta tows and spot dives located a few seagrass groups but the communities present were very sparse and vividly suffocated due to siltation.

Assessment of commercially important macro-invertebrates focusing on edible mollusks employing opportunistic sampling of shellfish in the seagrass bed was also undertaken. The location of the seagrass survey stations is presented in *Figure 84* (also please see *Plate 27*).

2.2.4.4.6 Rapid fisheries appraisals

Rapid fisheries appraisal was undertaken through key informant interviews to determine (i) dominant fishing gears used, (ii) common catch composition, (iii) estimated catch rates, and (iv) issues affecting fisheries. Observation of actual fishing operations to document catch per unit effort was undertaken in areas where fishers were actually operating hook and line and gill nets. Due to unproductive nearshore fisheries, there were no significant small-scale fishing operations witnessed in the study area in Candelaria. Most fishing operations were being undertaken in offshore Actual fishing documentation was conducted in two stations with coordinates listed in *Table 59* and mapped in *Figure 85.*

Table 59 - Coordinates of stations where actual fishing operations were documented for catch per unit effort and catch composition during the marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-08 May 2018.

WP Code	LATITUDE	LONGITUDE	REMARKS
AFE1	N 15.661475°	E 119.928346°	Located in Bgy Dampay; 2 fishers operating a drag net for the capture of milkfish fry. A CPUE of approx 4,000 milkfish fingerlings in a 3-hour span was documented.
AFE2	N 15.687615°	E 119.923841°	Located in Bgy Uacon with three fishers operating simple handlines to catch demersal fish. A CPUE of approximately 1.5 kg of assorted fish in a 6-hour span.

Plate 27 - Seagrass transect, corals in spot dive (upper left and right photos), two actual fishing operations documented in the survey (lower photos)

Figure 84 - Location of seagrass survey station during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

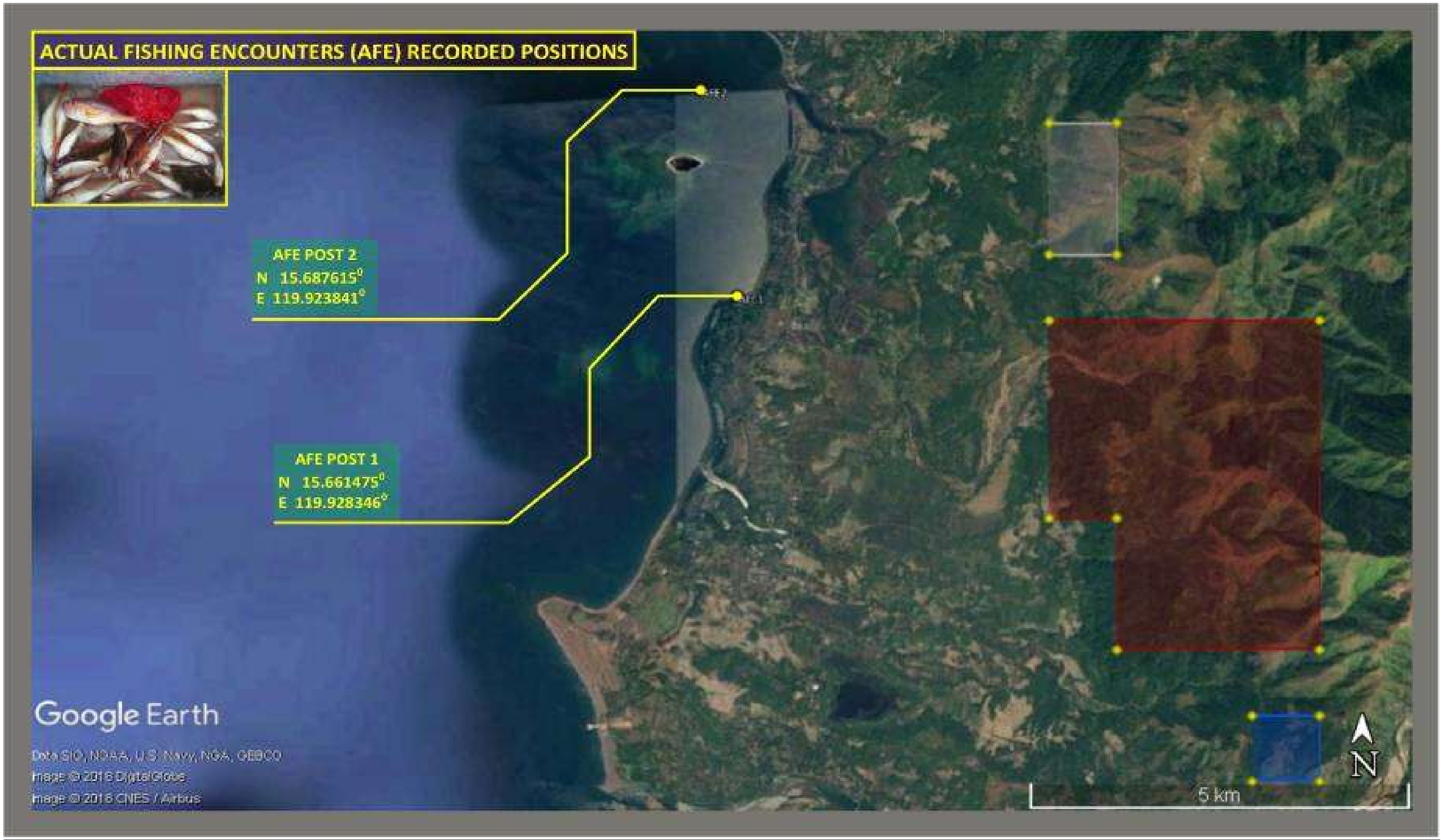


Figure 85 - Location of stations where actual fishing operations were documented during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

2.2.4.4.7 Mangrove Assessment

Initial survey impressions point to the presence of profuse mangrove stands in the small lakes and swamps in the inner region of Barangay Uacon and Malabon, as well as in the riverbanks of three major river systems. However, closer inspection revealed thin mangrove strips, particularly in the riverbanks. Three (3) stations were surveyed for species composition and distribution employing the standard transect-quadrant method, shown *Figure 86* (also see *Plate 28*). The coordinates of the mangrove survey stations are listed in *Table 62*.

Table 60 - Coordinates of mangrove community assessment stations surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018

WP Code	LATITUDE	LONGITUDE	REMARKS
MGV1	N 15.665680°	E 119.939740°	Located in the eastern corner of Uacon Lake where the most dense mangrove stands were observed. Other lakeside mangroves were too thin to permit full survey.
MGV2	N 15.635510°	E 119.929400°	Located in the banks of the Malabon River in Bgy Malabon, bordered by households and rice farms. Mangroves in the station were along a narrow strip of sandy-muddy bank.
MGV3	N 15.631460°	E 119.937420°	Located in Malabon River where a concrete flood control revetment has been built. Mangroves were contained in a small area accommodating only one quadrant. Other mangroves in the vicinity were sparse and scattered.

Plate 28 - Mangroves in station 1 in Uacon Lake (left) and station 3 in Malabon River (Right).

2.2.4.4.8 Plankton communities

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 four (4) sampling stations spread out in the coastal impact area of the proposed project. The coordinates of the sampling stations are listed in *Table 63* and shown in a map in *Figure 87*; also see *Plate 28*).

Table 61 - Coordinates of plankton community sampling stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMIn Nickel Project Candelaria, Zambales; 06-08 May 2018.

WP Code	LATITUDE	LONGITUDE	REMARKS
PLK1	N 15.603090°	E 119.904595°	Dominant phytoplankton *Chaetoceros* sp. at 245,860 cells/L, while dominant zooplankton are nauplius and copepodites (larval form) at 36,943 indiv/m^3
PLK2	N 15.641533°	E 119.917710°	Dominant phytoplankton *Chaetoceros* sp. at 87,898 cells/L, while dominant zooplankton are nauplius and copepodites (larval form) at 31,592 indiv/m^3
PLK3	N 15.670009°	E 119.918471°	Dominant phytoplankton *Chaetoceros* sp. at 107,431 cells/L, while dominant zooplankton are nauplius and copepodites (larval form) at 76,292 indiv/m^3
PLK4	N 15.688581°	E 119.930156°	Dominant phytoplankton *Chaetoceros* sp. at 136,306 cells/L, while dominant zooplankton are nauplius and copepodites (larval form) at 69,130 indiv/m^3

2.2.4.4.9 Survey of commercially-important macro-invertebrates and macro-benthos

Apart from the survey of benthos in conjunction with plankton community sampling, opportunistic surveys of macro-invertebrate of commercial significance for food and trade of local fishers was conducted in three (3) stations – two in LIT station 1 and 2 and a third station inside Uacon Lake. The coordinates the three macro-invertebrate and four benthos stations are shown in *Table 62* and mapped in *Figure 88* and *Figure 89.*

Table 62 - Coordinates of benthos and macro-invertebrate sampling stations in the coastal impact area of the proposed PHINMA Project in Argao, Cebu; 03-07 March 2018 (map prepared by Jose Rene Villegas).

WP Code	LATITUDE	LONGITUDE	REMARKS
BNT1	N 15.602169°	E 119.907011°	Total Density = 949 individuals with F Veneridae (Venus Clams, *Gafrarium* sp.) dominant @ 362 individuals.
BNT2	N 15.622685°	E 119.910799°	Total Density = 1,266 individuals with F Calcarinidae (Rotaliacean Foraminifera, *Calcarina* sp.) and F Peneroplidae (Benthic Foraminifera) both dominant at @ 317 individuals each respectively.
BNT3	N 15.661309°	E 119.927083°	Total Density = 1,898 individuals with F Calcarinidae (Rotaliacean Foraminifera, Calcarina sp.) dominant @ 1,176 individuals.
BNT4	N 15.689947°	E 119.932586°	Total Density = 4,252 individuals with F Calcarinidae (Rotaliacean Foraminifera, Calcarina sp.) dominant @ 2,534 individuals.

Table 63 - Macro-Invertebrate Diversity (MAC) Sampling Stations

WP Code	LATITUDE	LONGITUDEinside	REMARKS
MAC1	N 15.650878°	E 119.916126°	Same site as LIT1; sample specimens photo-documented
MAC2	N 15.680567°	E 119.932866°	Same site as LIT2; sample specimens photo-documented
MAC3	N 15.665680°	E 119.939740°	Located in mangrove survey station 1 inside Uacon Lake

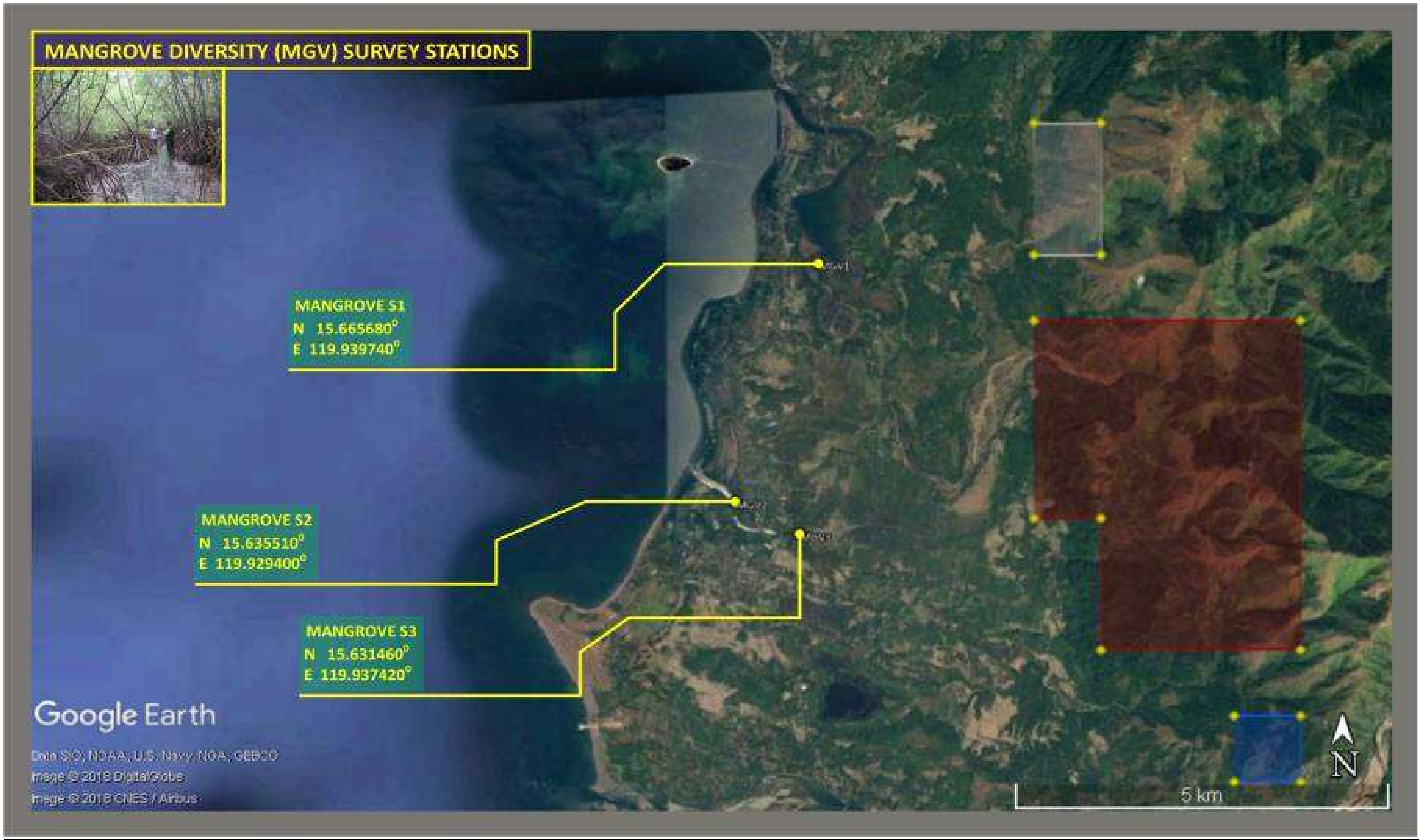


Figure 86 - Location of mangrove survey stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

Figure 87 - Location of plankton community sampling stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

Figure 88 - Location of benthos sampling stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

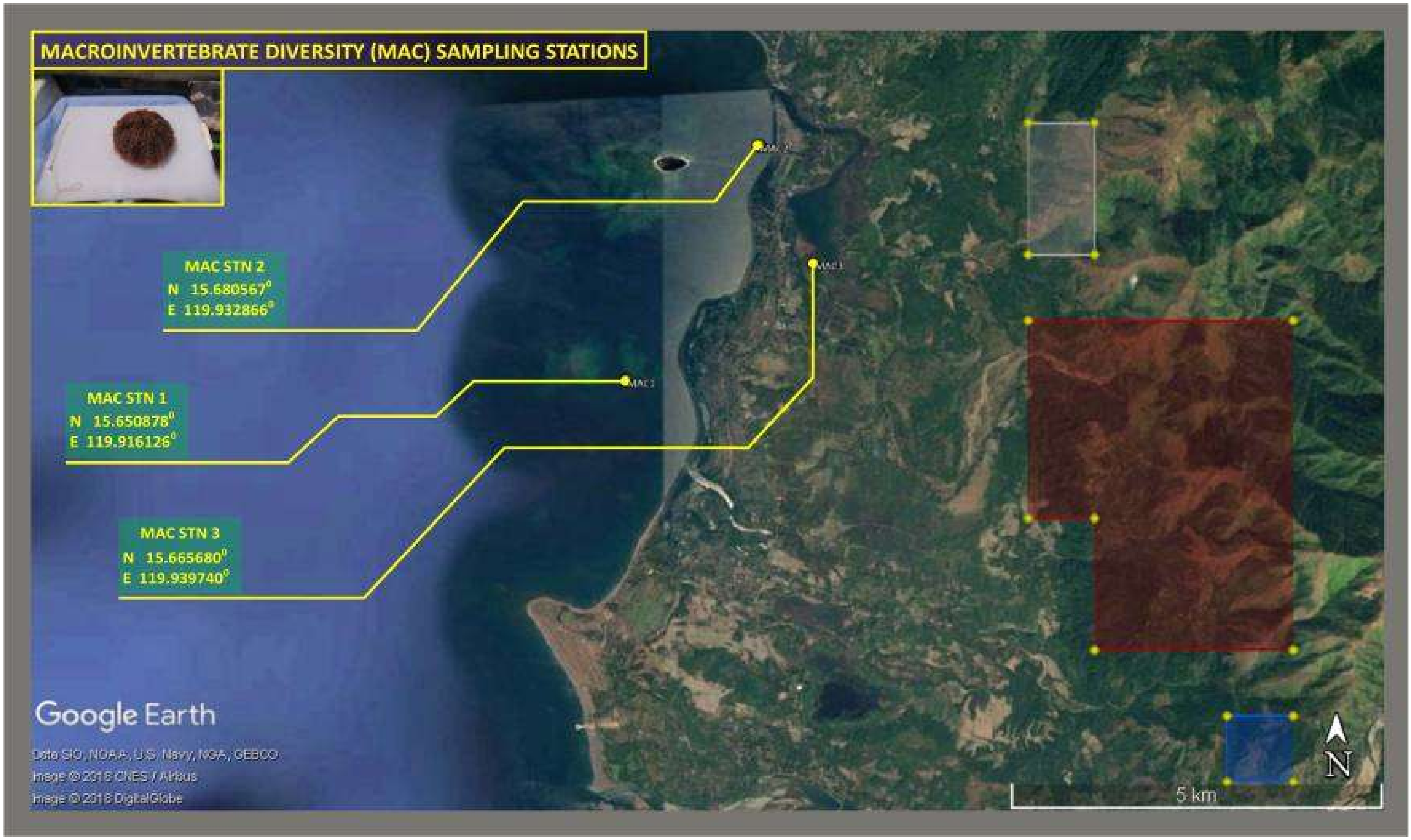


Figure 89 - Location of stations for opportunistic identification of commercially-important macro-invertebrates; marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by J ose Rene Villegas)

2.2.4.5 Results of Surveys

2.2.4.5.1 Overall survey impressions

A total of forty-seven (47) manta tow observation stations, three (3) line intercept stations for detailed coral reef assessment, three fish visual census stations for fish species richness and abundance, one (1) seagrass survey stations, three (3) mangrove survey quadrats, four (4) macro-benthos study sites, two (2) actual fishing sites and five (5) plankton stations were completed in the coastal impact area of the proposed nickel mining project in Candelaria, Zambales. Overall benthic environment profiling drawn from extensive manta tows paints a degraded reef flat with little seagrass meadows and unimpressive fish population. The result of the assessments indicate that the primary and secondary coastal impact area of the proposed nickel mining project hosts sporadic coral reefs that are currently already damaged, with corals of relatively fair condition existing only in two marine protected areas. The reef flats in several coastal Barangays in the impact area probably hosted a diverse coral reef colony in previous years but at the time of the survey, the reefs were dominated by dead corals with algae, obviously as a result of destructive fishing methods in the past and long-term sediment intrusion. The impaired reef flats are distinctly devoid of a diverse population of demersal species of fish and coral recruitment is scarce. Sediment intrusion is ubiquitous in the entire coastal waters in the impact area.

2.2.4.5.2 Coral Reef Distribution and Characterization

2.2.4.5.2.1 Results of 47 manta tow surveys for broad area benthic profiling

The summary of results for each manta tow stations are illustrated in *Figure 90, Figure 91* and *Figure 92* showing coral and substrate distribution, stations where corals were encountered and stations where dead corals with algae are dominant. The results are also tabulated in *Table 64*.

The overall benthic profile generated from the manta tow surveys revealed that abiotic components, in this case sand and silt, dominate the coastal impact area, with twenty-five (25) out of 47 manta tow stations comprised entirely of sandy substrate, and nine other stations comprising sand of between 60 to 80 percent of the substrate. This implies that the coastal impact area of the proposed nickel project is dominated by sand – around 79 % of the total area surveyed *(Figure 90)*.

Results from forty-seven manta tows conducted in a gently sloping nearshore shelf with a breadth of 100 to 150 meters from the shoreline revealed that corals are found in only eleven (11) points, or roughly a quarter of the survey corridor, with live coral cover ranging from 5 to 25%. In fact only two stations hosted the fair coral cover of 25% live hard coral cover (LHC), both inside the Sinabacan MPA, while the rest of the stations only had 5 to 10% live corals, most of which are vividly stressed. The corals occur in sporadic reef flats in Barangay Uacon to Sinabacan. Thereafter, the entire manta tow belt in the next three Barangays revealed sandy substrate, except in the Batong Lakay MPA which was located about 300 meters offshore in Barangay Sinabacan. Coral damage is vividly the result of destructive fishing practices and coral bleaching, among others, the use of explosives in fishing and the use of sodium cyanide to catch live fish. Of the forty-seven (47) manta tow benthic observations, twenty (20) stations in the reef flats were dominated by dead corals with algae, ranging from 10 to 90% of the benthic substrate. Sargassum sp and Padina sp covered the dead corals and settlement of new recruit appear to be unlikely (*Figure 92; Plate 29*). Across the tow stations, live hard coral cover was averaged at only 2%, while dead coral with algae was recorded at 18% (*Figure 90*).

In the Sinabacan MPA, however, live corals were robust, with old massive corals growing amidst an array of tabulate and branching corals. More importantly, coral recruits were present, indicating the presence of a source of planulae in the area. Schools of surgeonfishes and fusiliers were observed even in degraded patches.

Plate 29 - *Degraded reef flat observed in many manta tow stations with sandy substrate (upper photos); robust massive, branching and encrusting corals seen inside the MPAs*.

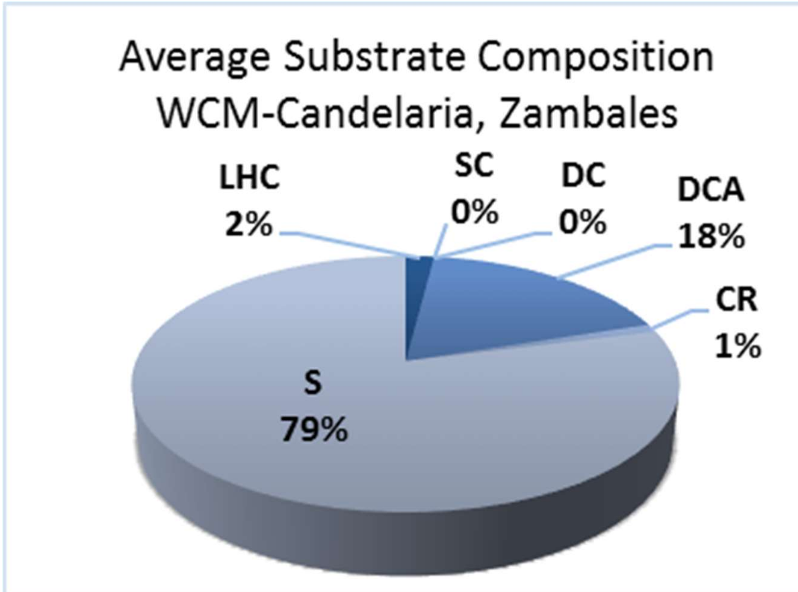


Figure 90 - Results of manta tow surveys in 47 benthic stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018.

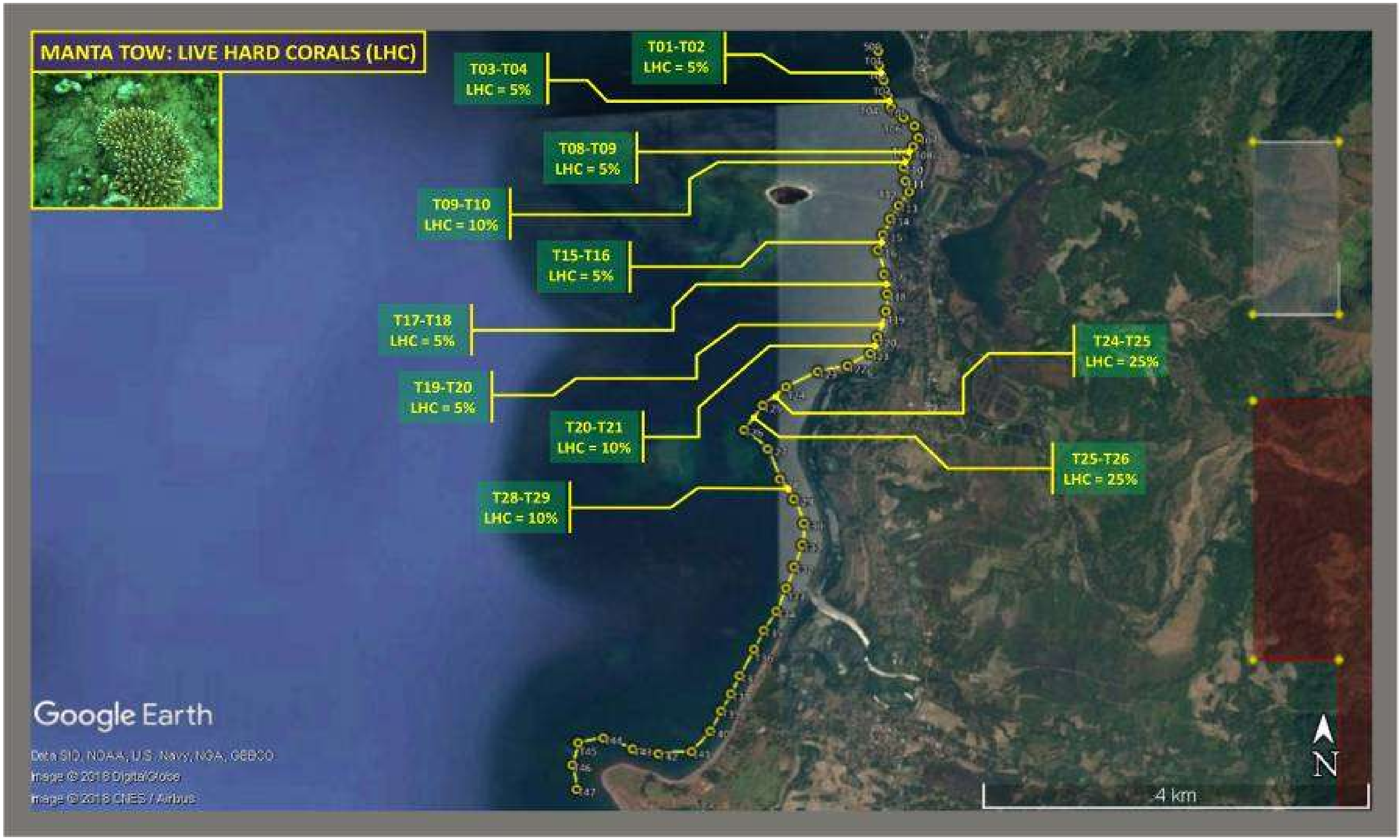


Figure 91 - Results of manta tow surveys showing stations were live corals were seen; marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene Villegas).

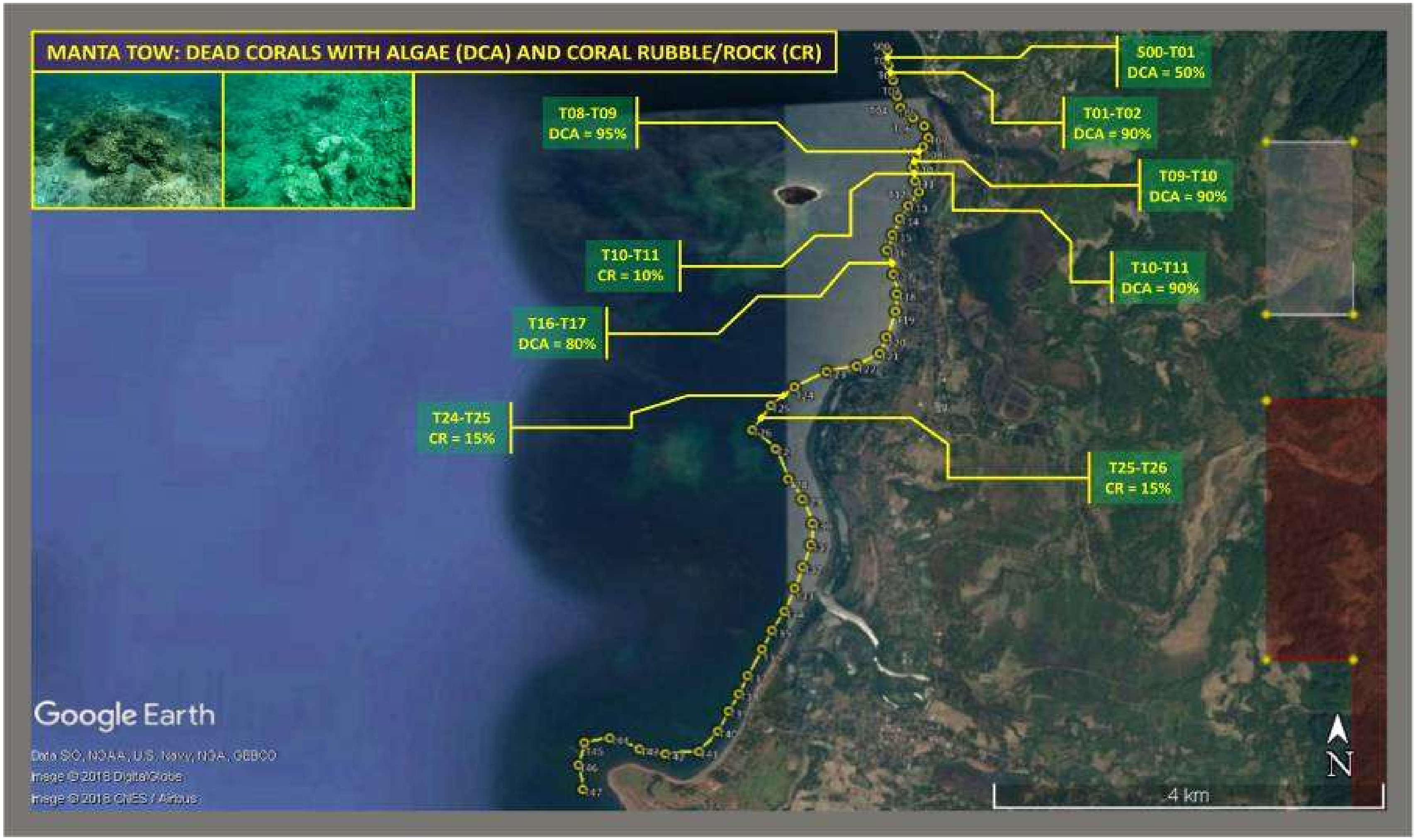


Figure 92 - Results of manta tow surveys showing stations with dead corals with algae; surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Quezon; 06-08 May 2018; (map by Jose Rene V Villegas)

Table 64 - Results of forty-seven (47) manta tows for coral and benthic substrate profiling over a 10.7 kilometer stretch of coastal waters in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; (Observers: Benj Francisco, Ernie Fontamillas).

MANTA TOW RESULTS FOR REEF AND SUBSTRATE SURVEY WESTCHINAMIN MINING PROJECT (CANDELARIA, ZAMBALES)									
Site name:		Offshore municipal waters west of Candelaria, Zambales							**Observers:**
Time / Date:		0835H-1228H / 06 June 2018							1. Benjamin Francisco 2. Ernie Fontamillas
Tow Speed:		4.0 kmh (ave)							
Visibility:		Varying from ±2m							
Weather:		Fair							
Wave:		Strong rolling crests of approx. ±50cm							
Current:		Varying from mild to lightly strong							
Tide:		Rising (0.55m to 0.77m) as ref from Santa Cruz Tidal Station (WXTIDE32)							
Water Temp:		Approx. ±30°C							
Wind Speed:		Beaufort Scale #2							
Cloud Type(s):		Cumulo-nimbus Clouds							
Tow Coverage	**Location [DecDeg]**	**LHC**	**SC**	**DC**	**DCA**	**R**	**S**		**Remarks**
S00	N 15.692120° E 119.930490°	-	-	-	-	-	-		Start of Tow; Northern boundary, Bgy Uacon
S00-T01	N 15.690720° E 119.930590°	0	0	0	50	0	50		Degraded corals, near Lucapon River estuary
T01-T02	N 15.689300° E 119.931020°	5	0	0	25	0	70		Heavily degraded corals, near Lucapon River estuary
T02-T03	N 15.687780° E 119.931410°	0	0	0	20	0	80		School of *Sardinella* sp.
T03-T04	N 15.686640° E 119.931720°	5	0	0	35	0	60		Highly degraded corals

T04-T05	N 15.685700° E 119.932950°	0	0	0	0	0	100	Widespread sand
T05-T06	N 15.684900° E 119.934000°	0	0	0	0	0	100	Widespread sand
T06-T07	N 15.683760° E 119.934390°	0	0	0	0	0	100	Widespread sand
T07-T08	N 15.682890° E 119.933870°	0	0	0	90	0	10	Highly degraded corals
T08-T09	N 15.681950° E 119.933260°	5	0	0	95	0	0	Heavily-silted corals; massive corals at reef crest
T09-T10	N 15.680910° E 119.932950°	10	0	0	90	0	0	Degraded corals; remaining forms are dominated by *Millepora* sp.
T10-T11	N 15.679580° E 119.933100°	0	0	0	90	10	0	Coral rubbles appear to be recent possibly caused by manual shattering
T11-T12	N 15.678540° E 119.933490°	0	0	0	20	0	80	Highly degraded reef flat
T12-T13	N 15.677210° E 119.932450°	0	0	0	0	0	100	Dead corals smothered with sand
T13-T14	N 15.675940° E 119.931650°	0	0	0	30	0	70	Reef flat with garbage and bleached massive corals
T14-T15	N 15.674400° E 119.930940°	0	0	0	20	0	80	Highly degraded reef flat with bleached corals
T15-T16	N 15.672900° E 119.930440°	5	0	0	40	0	55	Heavily degraded reef flat but with sparse corals
T16-T17	N 15.670600° E 119.931050°	0	0	0	80	0	20	Highly degraded reef slope across Dawal Resort
T17-T18	N 15.668700° E 119.931350°	5	0	0	25	0	70	Across boundary of Barangay Uacon

T18-T19	N 15.667020° E 119.931230°	0	0	0	0	0	100	Across boundary of Barangay Sinabacan
T19-T20	N 15.664540° E 119.930370°	5	0	0	15	0	80	Reef flat with sparse corals
T20-T21	N 15.662950° E 119.929720°	10	0	0	25	0	65	Reef flat
T21-T22	N 15.661740° E 119.927510°	0	0	0	0	0	100	Sinabacan-Manimanga MPA boundary
T22-T23	N 15.661200° E 119.924640°	0	0	0	0	0	100	Widespread sand
T23-T24	N 15.659720° E 119.921560°	0	0	0	0	0	100	Within Sinabacan-Manimanga MPA
T24-T25	N 15.657940° E 119.919300°	25	0	0	10	15	50	Reef slope within Sinabacan-Manimanga MPA
T25-T26	N 15.655570° E 119.917510°	25	0	0	25	15	35	Coral rubble at reef slope within Sinabacan-Manimanga MPA
T26-T27	N 15.653740° E 119.919770°	0	0	0	0	0	100	Across Bgy Manimanga; within Sinabacan-Manimanga MPA
T27-T28	N 15.650830° E 119.920950°	0	0	0	0	0	100	Widespread sand and deep water within Sinabacan-Manimanga MPA
T28-T29	N 15.648900° E 119.922320°	10	0	0	20	0	70	Degraded corals with a few live forms; mostly sandy substrate
T29-T30	N 15.646570° E 119.923290°	0	0	0	0	0	100	Across Barangay Malabon
T30-T31	N 15.644480° E 119.923130°	0	0	0	0	0	100	Widespread sand
T31-T32	N 15.642360° E 119.922340°	0	0	0	0	0	100	Widespread sand

T32-T33	N 15.640300° E 119.921570°	0	0	0	0	0	100	Widespread sand
T33-T34	N 15.638070° E 119.920600°	0	0	0	0	0	100	Widespread sand
T34-T35	N 15.636240° E 119.919400°	0	0	0	0	0	100	Widespread sand
T35-T36	N 15.634410° E 119.918460°	0	0	0	0	0	100	Across Barangay Libertador
T36-T37	N 15.631860° E 119.917070°	0	0	0	0	0	100	Widespread sand
T37-T38	N 15.630110° E 119.916240°	0	0	0	0	0	100	Widespread sand
T38-T39	N 15.628460° E 119.915280°	0	0	0	0	0	100	Widespread sand
T39-T40	N 15.626520° E 119.914230°	0	0	0	0	0	100	Widespread sand
T40-T41	N 15.624550° E 119.912420°	0	0	0	0	0	100	Widespread sand
T41-T42	N 15.624320° E 119.909220°	0	0	0	0	0	100	Across Barangay Dampay
T42-T43	N 15.624790° E 119.906730°	0	0	0	0	0	100	Widespread sand
T43-T44	N 15.625860° E 119.903880°	0	0	0	0	0	100	Widespread sand
T44-T45	N 15.625390° E 119.901450°	0	0	0	0	0	100	Widespread sand
T45-T46	N 15.623250° E 119.900890°	0	0	0	0	0	100	Widespread sand

T46-T47	N 15.620900° E 119.901310°	0	0	0	20	0	80	Across promontory at Barangay Binabalian; end of tow
Average Reef and Substrate Composition		**2**	**0**	**0**	**18**	**1**	**79**	

- Tow points are expressed in Decimal Degrees WCS notation with 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)

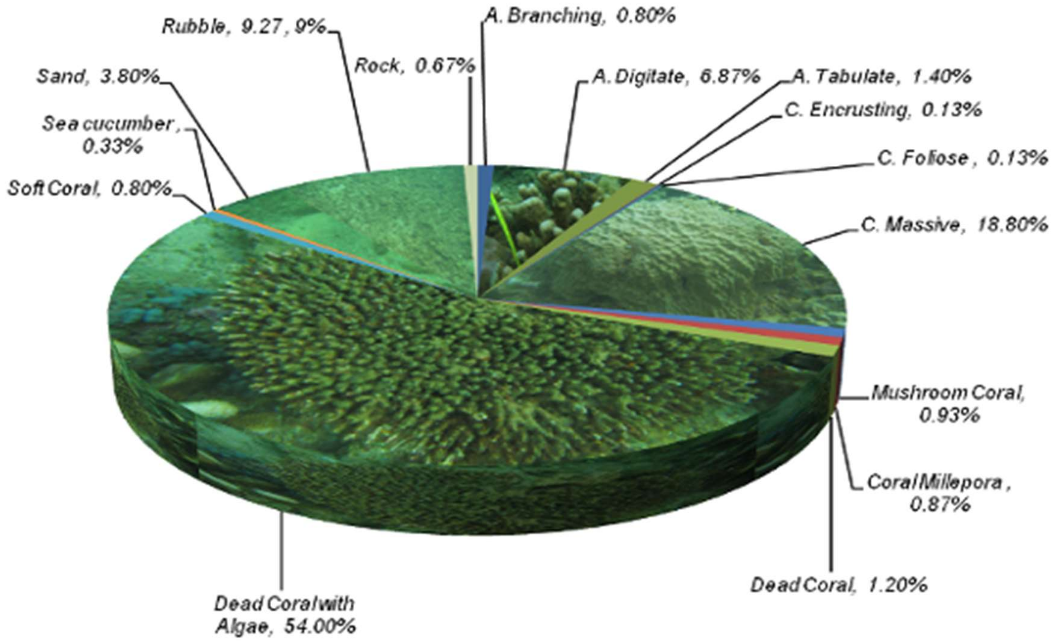
2.2.4.5.3 Results of detailed coral surveys in three Line Intercept Transects

Three LIT stations for recording detailed coral cover and benthic life forms associated with coral reefs were laid out in a relatively good patch of corals along the reef slope in tow MPAs and a third transect station in a reef flat in Barangay Uacon, Candelaria. Corals in the MPAs are the only major coral stations and only intermittent patches of corals occur elsewhere, with dead corals with algae dominating the reefs.

Across the three stations, the average live coral cover was documented at 23 percent (*Table 65*) - categorized as "Fair" in standard coral grading (*Gomez, et. al., 1981*). The reef is dominated by massive *Porites* colonies, accounting for almost 19% of all live coral cover, particularly in the two MPAs (*Figure 93*). The massive corals consisted of old colonies and recruits. Digitate corals (*Acropora digitifera; Montipora digitata)* as well as branching Acropora (*Acropora indonesia, Pocillopora elegans, Montipora hirsute, among others),* were also encountered but these varieties comprised only more than 7% of the colonies. Encrusting corals (e.g., *Montipora mactanensis)* and mushroom corals (Fungia spp), foliose and the fire coral *Millepora* altogether comprised 2% of the community. Dead corals with algae – dominant in station 3 – was registered at 54% across the three stations while coral rubble – indicating old damage by blast fishing – comprised almost 9.3 % of the reef in the survey area. In particular, dead corals with algae comprised 93% in station 3 in Barangay Uacon. This site is near the Uacon River estuary.

Table 65 - Average percentage cover of the different lifeform categories across three (3) LIT transects located within Batong Lakay and Sinabacan-Malimanga MPAs; and across Puerto del Mar Resort in Barangay Uacon, Candelaria, Zambales Province; June 06-07, 2018. (Observers: Victor L. Pantaleon and Ronald T. Pocon).

LIFEFORM CATEGOTES		**CODE**	**AVERAGE PERCENTAGE COVER** *(in %)*
Acropora	*Branching*	*ACB*	**0.80**
	Digitate	*ACD*	**6.87**
	Tabulate	*ACT*	**1.40**
Non-Acropora	*Encrusting*	*CE*	**0.13**
	Foliose	*CF*	**0.13**
	Massive	*CM*	**18.80**
	Mushroom Coral	*CMR*	**0.93**
	Coral Millepora	*CME*	**0.87**
AVERAGE PERCENT LIVE HARD CORAL (LHC) COVER			***29.93 Fair Condition***
Dead Coral		*DC*	**1.20**
Dead Coral with Algae		*DCA*	**54.00**
Other Fauna	*Soft Coral*	*SC*	**0.80**
	Sea cucumber	*OT*	**0.33**
Abiotic	*Sand*	*S*	**3.80**
	Rubble	*R*	**9.27**
	Rock	*RCK*	**0.67**



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

Figure 93 - Relative distribution, in percentages, of coral life forms, abiotic components and other fauna catalogued in three (3) LIT transects located within Batong Lakay and Sinabacan-Malimanga MPAs; and across Puerto del Mar Resort in Barangay Uacon, Candelaria, Zambales Province; June 06-07, 2018. (Observers: Victor L. Pantaleon and Ronald T. Pocon).

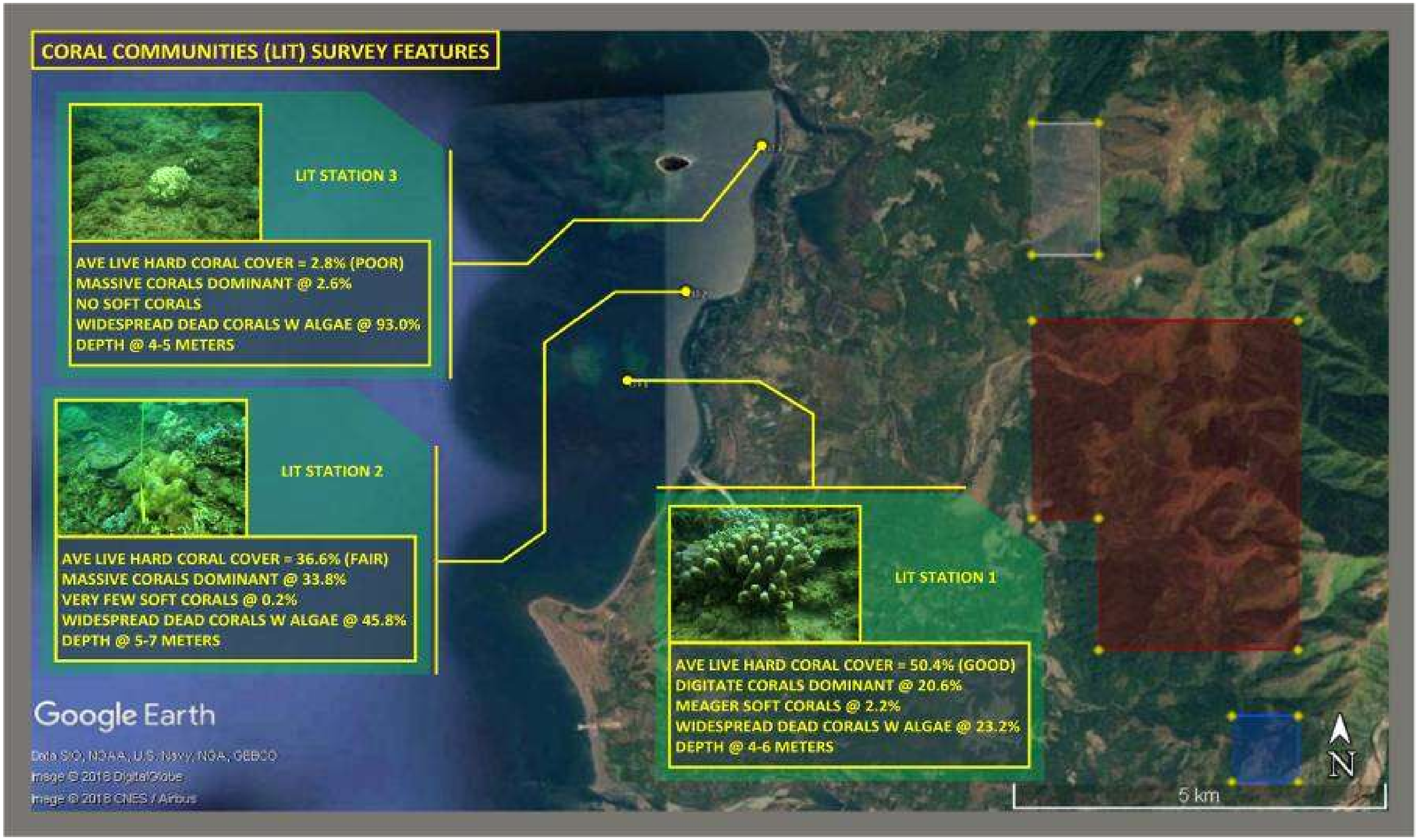


Table 66 - ***Location and average percentage cover of the different coral lifeforms in standard categories across three (3) LIT transects located within Batong Lakay and Sinabacan-Malimanga MPAs; and across Puerto del Mar Resort in Barangay Uacon, Candelaria, Zambales Province; surveyed during marine ecology baseline assessment; June 06-07, 2018. (Observers: Victor L. Pantaleon and Ronald T. Pocon).***

On a per station basis, the corals in the reef slope in Transect 1 – inside the Batong Lakay MPA, hosted a good community of live corals with 50.40 % live coral cover dominated by digitatet and massive coral species, altogether accounting for 81% of live corals in the survey corridor (*Table 66; Figure 94*). Branching, tabulate and *Millepora* corals comprised 9% of the live coral community combined **(***Figure 95*; also please see *Plate 30*). The reef slope is solid – with thin strips of sand in between coral colonies (7%). However, dead corals with algae comprised 23.2% and old coral rubble comprising almost 15% of the transect area. In this station, coral recruitment appears to be robust, even as coastal waters were turbid at the time of the LIT survey. The entire reef is estimated to be around 2 hectares, more or less, including the reef flat where intermittent sandy substrate was common.

Transect 2 – inside the Sinabacan-Malimanga MPA hosted only fair coral cover with live hard corals comprising 36.6% across the station (*Table 67* massive corals, accounting for and *Figure 95*). The corals were dominated almost exclusively by 34% of all live corals. Mushroom corals comprised the remaining live corals. The branching and tabulate corals in this station have been overcome with algae comprising 49% of the coral reef slope. Mortality of the corals appears to have been caused by use of explosives and cyanide in fishing but the damage marks are old. Rubble consisted of 12.6%.

There was no significant live corals remaining in LIT station 3 where the survey along the 50-meter transect line recorded only 2.80% live coral cover. The entire reef flat was almost comprised entirely of dead corals with algae, registered at 93% of the substrate in the transect line. Sand and coral rubble comprised the 4.2% of the surveyed area (*Table 67* and *Figure 94*). The few live corals that are surviving were comprised of massive corals that are already gradually being overcome by algal encrustation due to turbid waters and sporadic remnants of branching corals. The demise of the corals over the broad reef flat appears to have been caused by use of cyanide and explosives in fishing.

A total of thirty-one (31) species of corals were catalouged across the three LIT transects dominated by massive species *Lobophyllia hemprichii, Porites lutea, Porites lobata, Leptoria otsp,* among others, and branching corals encountered in stations 1 – Acropora *robusta, Acropora Indonesia,* digitate *Acropora digitifera* and foliose *Montipora spp.(Table 68).*

Table 67 - Distribution/station (in % of total coral cover) of coral lifeforms in three LIT transects - Batong Lakay, Sinabacan-Malimanga MPA and across Puerto del Mar Resort in Barangay Uacon, Candelaria, Zambales Province; marine ecology baseline June 06-07, 2018. (Observers: Victor L. Pantaleon and Ronald T. Pocon).

Name of Site: Bgys Uacon, Sinabacan, Malimanga			**Municipality & Province:** Candelaria, Zambales		
Date: June 6 - 7, 2018			**Observers:** Victor L. Pantaleon & Ronald T. Pocon		
Location:				**Depth** *(in meters)*:	
***Survey Station 1* (LIT1)**					
Start: N 15.650878° E 119.916126°; End: N 15.651288° E 119.915928°				4 - 6 meters	
***Survey Station 2* (LIT2)**					
Start: N 15.662158° E 119.923407°; End: N 15.661735° E 119.923261°				5 - 7 meters	
***Survey Station 3* (LIT3)**					
Start: N 15.680567° E 119.932866°; End: N 15.681010° E 119.932930°				4 - 5 meters	
LIFE CATEGORIES		**CODE**	**DISTRIBUTION per TRANSECT** *(in %)*		
			1	**2**	**3**
Acropora	*Branching*	*ACB*	2.20		0.20
	Digitate	*ACD*	20.60		
	Tabulate	*ACT*	4.20		
Non-Acropora	*Encrusting*	*CE*	0.40		
	Foliose	*CF*	0.40		
	Massive	*CM*	20.00	33.80	2.60
	Mushroom Coral	*CMR*		2.80	
	Coral Millepora	*CME*	2.60		
AVERAGE % LIVE HARD CORAL COVER			**50.40 *(Good)***	**36.60 *(Fair)***	**2.80 *(Poor)***
Dead Coral		*DC*	1.20	2.40	
Dead Coral with Algae		*DCA*	23.20	45.80	93.00
Other Fauna	*Soft Coral*	*SC*	2.20	0.20	
	Sea cucumber	*OT*	0.80	0.20	

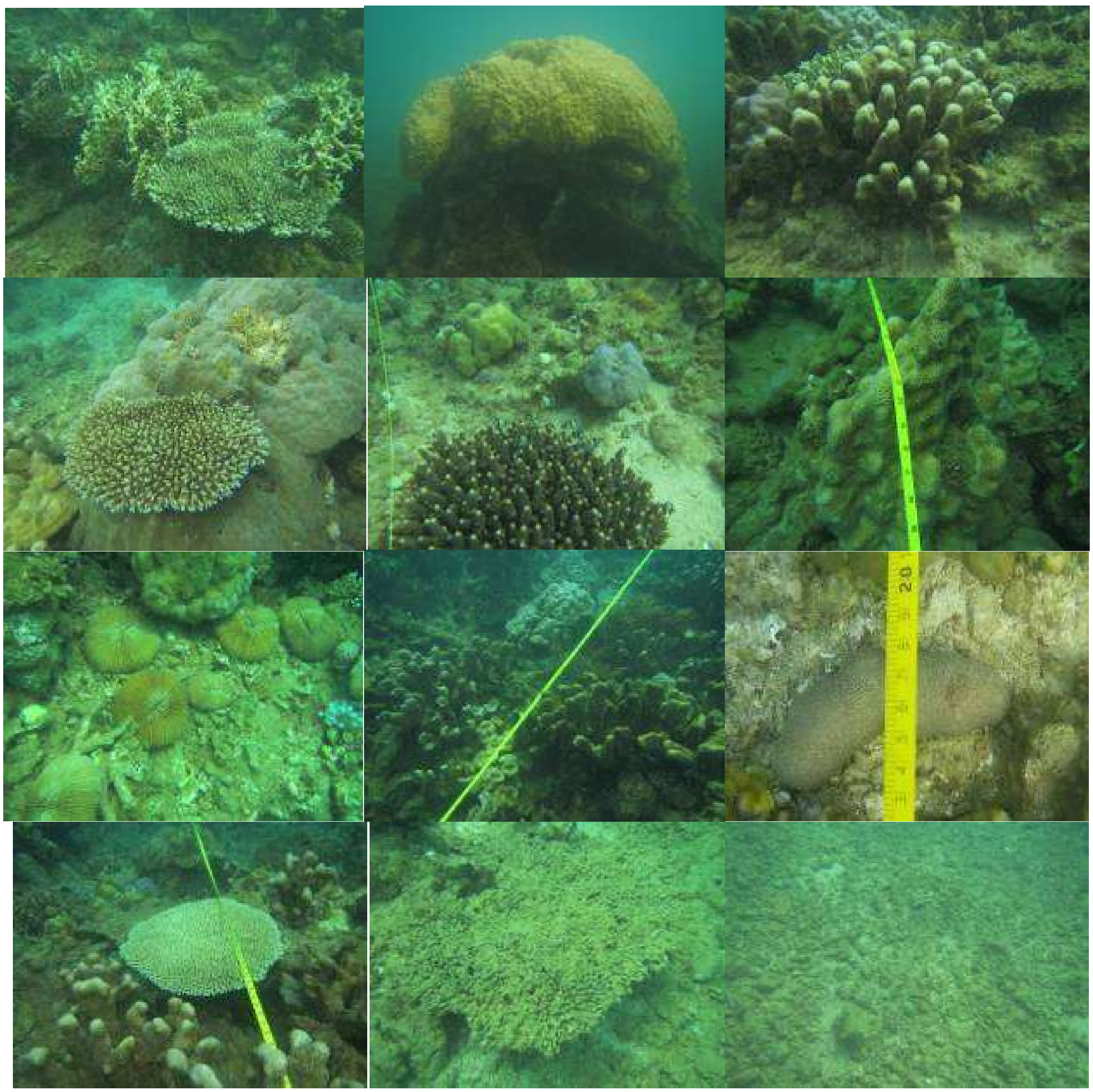
	Sand	*S*	7.00	0.80	3.60
Abiotic	*Rubble*	*R*	14.60	12.60	0.60
	Rock	*RCK*	0.60	1.40	

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

Table 68 - Some coral species encountered in three (3) LIT stations observed within Batong Lakay and Sinabacan-Malimanga MPAs; and across Puerto del Mar Resort in Barangay Uacon, Candelaria, Zambales Province; June 06-07, 2018. (Observers: Victor L. Pantaleon and Ronald T. Pocon).

Massive	Branching	Digitate, Encrusting, Mushroom, Foliose, Soft Corals & Others (Sea cucumber, Feather stars)
Leptoria species Lobophyllia dentatus *Lobophyllia hemprichii* Montipora caliculata Montipora efflorescens Porites brighami Porites lutea Porites lobata Porites species	Acropora indonesia Acropora donei Acropora robusta *Montipora hirsuta* *Pocillopora elegans* Porites nigrescens	Acropora digitifera Acropora ocellata Montipora digitata Montipora spumosa Montipora cebuensis Montipora mactanensis Cycloseris species *Ctenactis echinata* Fungia donae, Fungia granulosa, Fungia paumotensis Montipora foliosa Millepora platyphylla Millepora alcicornis Holothuria lessoni Oxycomanthus bennetti

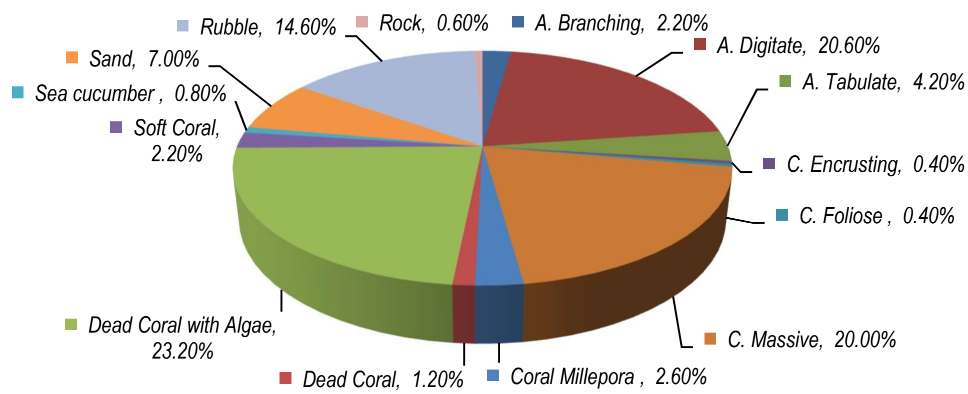
Plate 30 - ***Actual photographs showing the dominant live hard, soft corals, associated fishes and sea cucumber in the survey site. Top row left to right: Fire Coral (Millepora alcicornis) & Table-form Coral (Acropora donei); Porites lobata; 2nd row: table-form coral (Acropora donei) recruits above massive coral (Porites lutea); Digitate-form Coral (Acropora ocellata) with Damselfish "PATA" (Dascyllus reticulatus) that have taken refuge in the scleractinian finger-like branching coral recruit; Common Massive Coral (Porites brighami); 3rd row: aggregate of solitary mushroom-form Corals (Fungia donae, Fungia granulosa, Fungia paumotensis, Ctenactis echinata) and Soft coral with anvil-like heads (Sarcophyton crassocaule); 4th row: dead table-form coral (Acropora Indonesia) overgrown with algae; silted dead coral and rubbles with algae. (Underwater images taken on June 06 -07, 2018, Victor L. Pantaleon and Ronald T. Pocon).***



Transect 1 (LIT1)

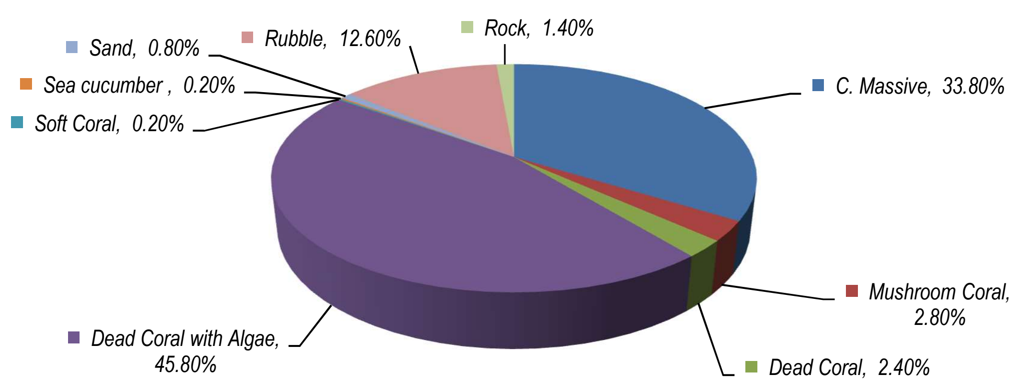
Location: Start: N 15.650878° E 119.916126°; End: N 15.651288° E 119.915928°

Within Batong Lakay MPA, Barangay Libertador, Candaleria, Zambales



Transect 2 (LIT2)

Location: Start: N 15.662158° E 119.923407°; End: N 15.661735° E 119.923261°
Within Sinabacan-Malimanga MPA, Barangay Sinabacan and Malimanga,, Candelaria, Zambales



Transect 3 (LIT3)

Location: Start: N 15.680567° E 119.932866°; End: N 15.681010° E 119.932930°
Across Puerto Del Mar Beach Resort, Barangay Uacon, Candelaria, Zambales

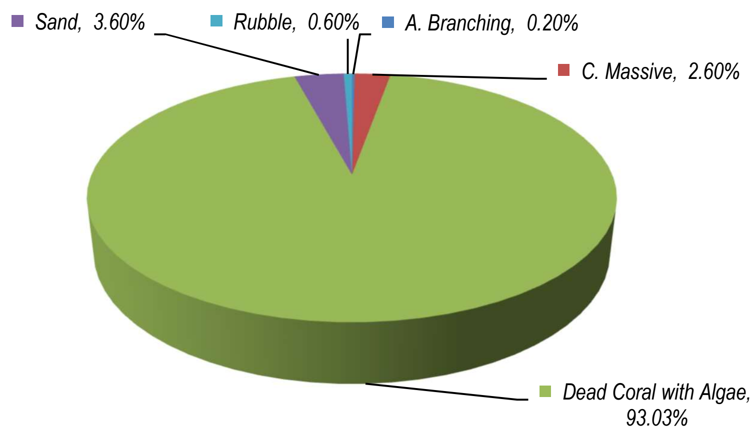


Figure 94 - *Results from line intercept survey for benthic lifeform distribution in three (3) stations located in the Batong Lakay, Sinabacan-Malimanga MPAs and across Puerto del Mar Resort in Barangay Uacon and Sinabacan, Candelaria, Zambales Province; June 06-07, 2018. (Observers: Victor L. Pantaleon and Ronald T. Pocon).*

2.2.4.5.4 <u>Results of Spot Dives</u>

Spot dives 1 and 2, conducted to verify coral patches not covered by the LIT and manta tow surveys, revealed poor to fair coral cover similar to results of the line intercept surveys. Spot dive 1 in a reef patch that appeared to be an extension of the fringing reef southeast of the Batong Lakay MPA revealed live hard coral cover of 40% (lower range of 'Good' condition) and 50 % dead corals with algae and coral rubble (*Figure 95*). The corals in spot dive station 1 are outside of the MPA boundaries. Spot station 2 – located in the southeastern coast of Potipot island was found out to be a degrade reef with live coral cover of 15%, dead corals with algae at 40% and coral rubble at 30% of the survey corridor. Nevertheless, the corals in spot dive station 2 are relatively in a far better condition than the coral reef flat catalogued in the LIT station 3 in Bgy Uacon where the entire expanse of reef was almost completely comprised of dead corals with algae. These two separate coral spots represents 'other' reef areas in the coastal impact area where live corals are found to be with better profiles than those in the inshore shelf.

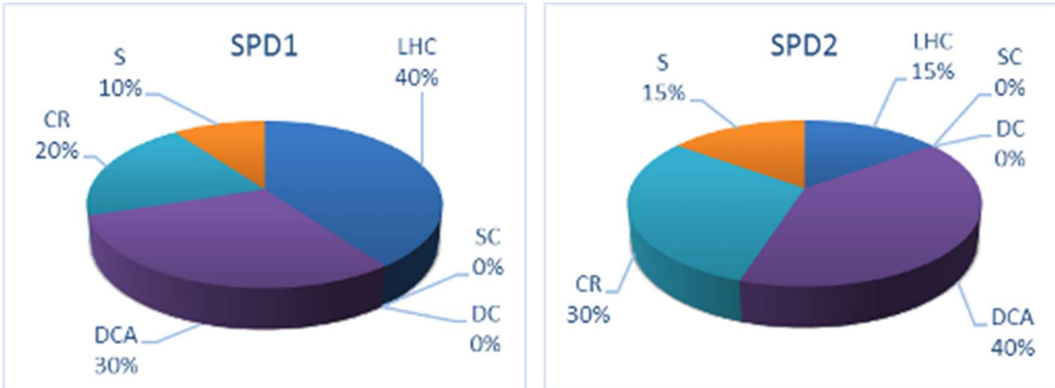


Figure 95 - *Results of spot dives in two coral reef areas in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-07 June 2018.*

Findings from the spot dives are summarized in a map in *Figure 96.*

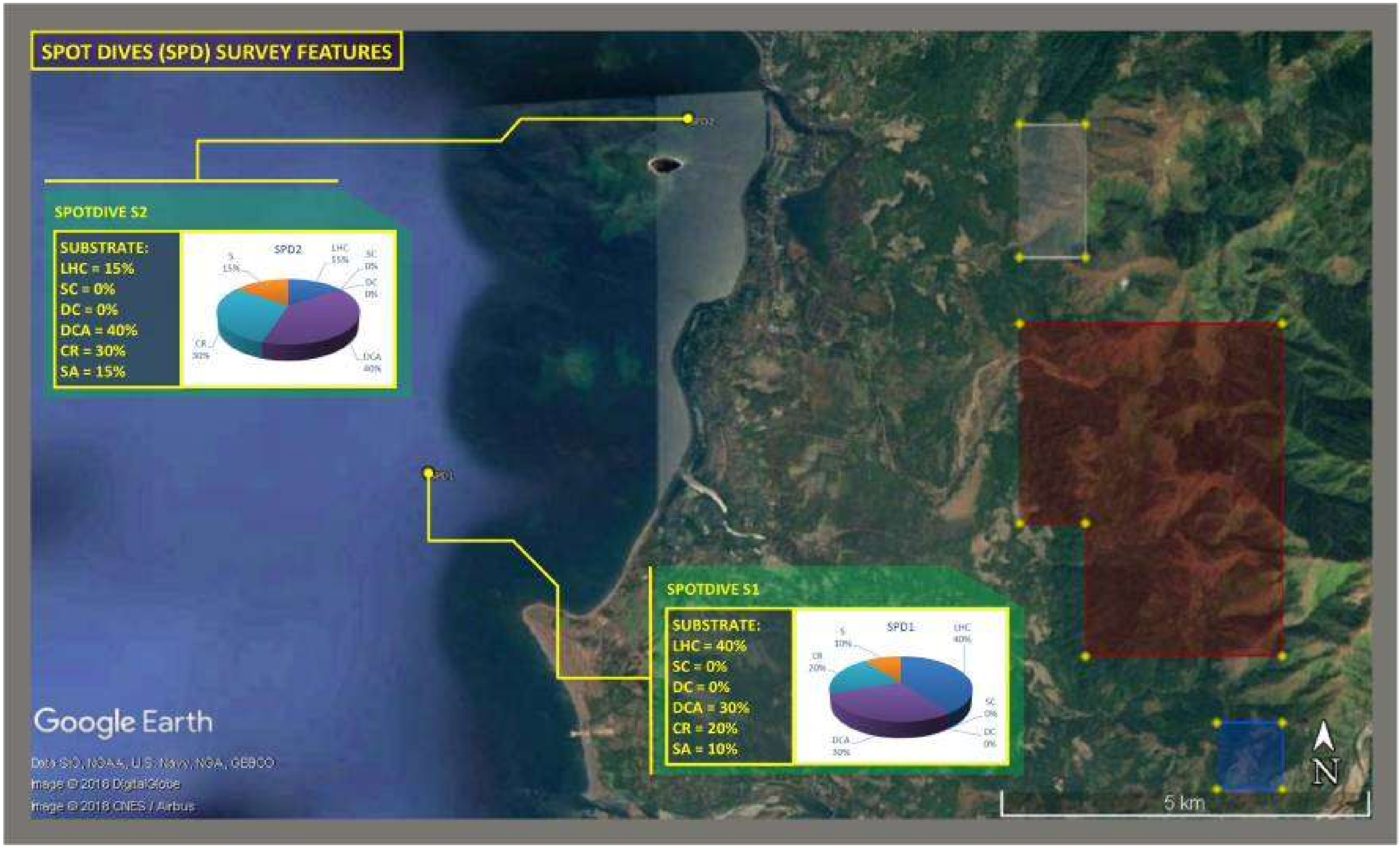


Figure 96 - Highlights of results of fish visual census for species richness and abundance in three FVC stations surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; June 20

2.2.4.5.5 Survey Results for Associated Reef Fish Communities and other Demersal Marine Fauna

The absence of a significant distribution of live coral cover and poor condition of benthic substrates in two LIT stations (LIT station 2 and 3) yielded low significant fish population and species richness compared to Station 1 where live coral cover was recorded at more than 50% LHC and coral diversity consisting of more than 30 species.

A total of 488 fish individuals were catalogued in three fish visual census stations with forty-six (46) species in fourteen (14) family taxa (*Table 69*). This represents a low fish density of 0.32 fish per square in 1500 m^2 of survey area. Total fish abundance was pulled down by very low numbers of fish in FVC stations 2 and 3 (the Sinabacan-Malimanga MPA where live corals were recorded at only 36% and in the reef flat across Puerto del Mar Resort with live corals at only 2.8%, respectively). Fish abundance was recorded at 59 individuals in station 2 and 64 individual fish in station 3. On the other hand, total fish individuals recorded in Station 1 reached 365, or 75% of the fish population encountered in the survey, and 91% of species richness (*Table 69* and *Figure 97*).

Typically gregarious, the damselfishes dominated the fish population across the three stations, accounting for 38% of abundance, with nine (9) species dominated by the staghorn damsel *Amblyglyphidodon curacao.* Other than the damsels, surgeonfishes and parrotfish, totaling 60 and 66 individuals, respectively, comprised 26% of the fish population across the three transects (*Figure 97*). There were four (4) species of Acanthurids and three (3) species of parrotfish. The wrasses – with 49 individuals, consisted of eleven (11) species. Most of these species were encountered in station 1.

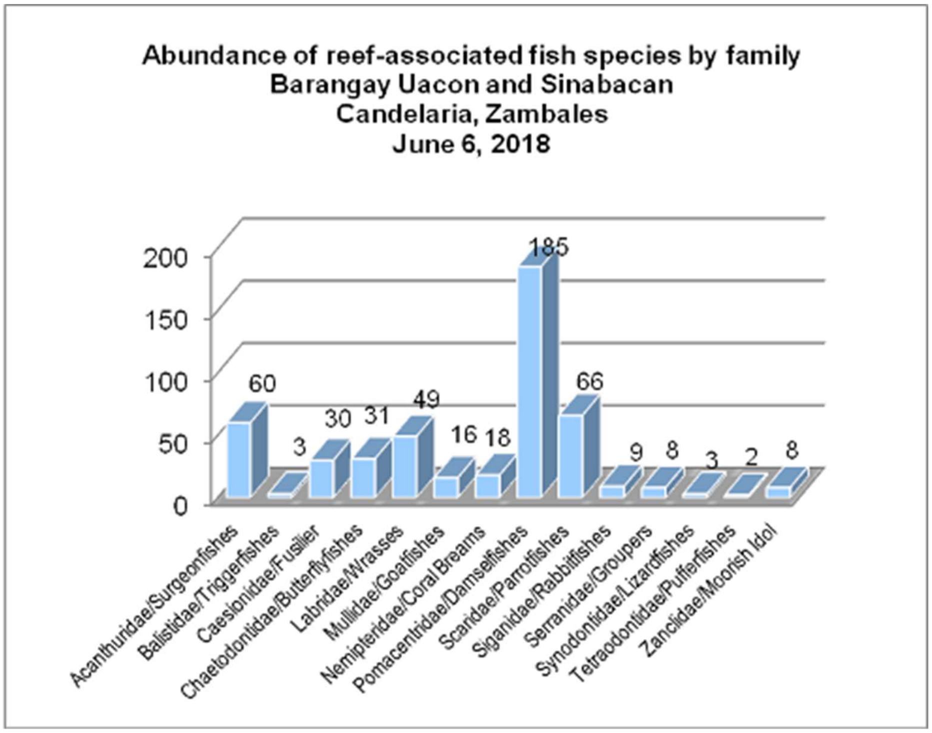


Figure 97 - Fish abundance by family taxa catalogued in three FVC stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-07 June 2018

Table 69 - Fish species richness and abundance catalogued in three FVC stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-07 June 2018

FISH ABUNDANCE DATA FORM										
Site Name: Across Barangays Uacon and Sinabacan				Municipality & Province: Candelaria, Zambales						
Date: June 06-07, 2018				Observers: Rowena R. Quimpo						
				Depth(m): 6-15 meters						
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126° - within Batong Lakay MPA									
	Station No. 2 (FVC2) - N 15.662158° E 119.923407° - within Sinabacan-Malimanga MPA									
	Station No. 3 (FVC3) - N 15.680567° E 119.932866° - area across Puerto del Mar Resort									
FAMILY	**SCIENTIFIC NAME**	**COMMON NAME**	**LOCAL NAME**	**Station 1**		**Station 2**		**Station 3**		**Total # of indivi-duals**
				# of ind	**Size (cm)**	**# of ind**	**Size *(cm)***	**# of ind**	**Size *(cm)***	
Acanthuridae	*Acanthurus lineatus*	Blue-lined surgeonfish	Labahita	15	6	3	4	8	6	**26**
Acanthuridae	*Zebrasoma scopas*	Brushtail tang	Indangan	10	8					**10**
Acanthuridae	*Acanthurus nigricans*	White cheek surgeonfish	Labahita			10	8	2	8	**12**
Acanthuridae	*Acanthurus pyroferus*	Chocolate surgeonfish	Labahita	8	4					**8**
Acanthuridae	*Naso lituratus*	Orange-spine unicornfish	Surahan, Giboy	4	8					**4**
Balistidae	*Balistapus undulatus*	Orange-lined triggerfish	Pakol, Pugot	2	10	1	8			**3**

FISH ABUNDANCE DATA FORM		
Site Name: Across Barangays Uacon and Sinabacan		Municipality & Province: Candelaria, Zambales
Date: June 06-07, 2018		Observers: Rowena R. Quimpo Depth(m): 6-15 meters
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126° - within Batong Lakay MPA	
	Station No. 2 (FVC2) - N 15.662158° E 119.923407° - within Sinabacan-Malimanga MPA	
	Station No. 3 (FVC3) - N 15.680567° E 119.932866° - area across Puerto del Mar Resort	

FAMILY	SCIENTIFIC NAME	COMMON NAME	LOCAL NAME	Station 1		Station 2		Station 3		Total # of indivi-duals
				# of ind	Size (cm)	# of ind	Size *(cm)*	# of ind	Size *(cm)*	
Caesionidae	*Pterocaesio tessellata*	One-stripe fusilier	Sulid	30	4					**30**
Chaetodontidae	*Chelmon rostratus*	Copperband butterflyfish	Paru-paro	2	8					**2**
Chaetodontidae	*Chaetodon adiergastos*	Philippine butterflyfish	Paru-paro	3	8					**3**
Chaetodontidae	*Chaetodon melannotus*	Black-backed butterflyfish	Paru-paro	2	6					**2**
Chaetodontidae	*Chaetodon baronessa*	Eastern Triangular butterflyfish	Paru-paro	4	6	3	8	1	6	**8**
Chaetodontidae	*Chaetodon lunulatus*	Oval butterflyfish	Paru-paro	4	8					**4**
Chaetodontidae	*Chaetodon octofasciatus*	Eight-banded butterflyfish	Paru-paro	6	6					**6**

FISH ABUNDANCE DATA FORM										
Site Name: Across Barangays Uacon and Sinabacan				Municipality & Province: Candelaria, Zambales						
Date: June 06-07, 2018				Observers: Rowena R. Quimpo						
				Depth(m): 6-15 meters						
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126° - within Batong Lakay MPA									
	Station No. 2 (FVC2) - N 15.662158° E 119.923407° - within Sinabacan-Malimanga MPA									
	Station No. 3 (FVC3) - N 15.680567° E 119.932866° - area across Puerto del Mar Resort									
FAMILY	**SCIENTIFIC NAME**	**COMMON NAME**	**LOCAL NAME**	**Station 1**		**Station 2**		**Station 3**		**Total # of indivi-duals**
				# of ind	**Size (cm)**	**# of ind**	**Size *(cm)***	**# of ind**	**Size *(cm)***	
Chaetodontidae	*Heniochus varius*	Humphead bannerfish	Paru-paro	3	10	1	6	2	7	**6**
Labridae	Hemigymnus melapterus	Banner wrasse	Labayan			3	10			**3**
Labridae	*Thalassoma lunare*	Moon Wrasse	Labayan	13	8			4	6	**17**
Labridae	*Thalassoma hardwicke*	Sixbar Wrasse	Labayan	6	8					**6**
Labridae	*Cheilinus trilobatus*	Tripletail Wrasse	Ipospadi;Ipos-ipos	2	12	1	7	2	6	**5**
Labridae	*Cheilinus undulates*	Humphead wrasse	Ipospadi: Maming	1	10					**1**
Labridae	*Cheilinus fasciatus*	Red-breasted wrasse	Buanting, Labayan	3	6			1	4	**4**

FISH ABUNDANCE DATA FORM

Site Name: Across Barangays Uacon and Sinabacan		Municipality & Province: Candelaria, Zambales
Date: June 06-07, 2018		Observers: Rowena R. Quimpo
		Depth(m): 6-15 meters
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126°	- within Batong Lakay MPA
	Station No. 2 (FVC2) - N 15.662158° E 119.923407°	- within Sinabacan-Malimanga MPA
	Station No. 3 (FVC3) - N 15.680567° E 119.932866°	- area across Puerto del Mar Resort

FAMILY	SCIENTIFIC NAME	COMMON NAME	LOCAL NAME	Station 1		Station 2		Station 3		Total # of indivi-duals
				# of ind	Size (cm)	# of ind	Size *(cm)*	# of ind	Size *(cm)*	
Labridae	*Oxycheilinus digramma*	Cheeklined wrasse	Labayan	4	4					**4**
Labridae	*Halichoeres chloropterus*	Pastel-green wrasse	Luday	2	6	3	8			**5**
Labridae	*Choerodon oligacanthus*	White-patch tuskfish	Labayan	1	4					**1**
Labridae	*Leptojulis cyanopleura*	Shoulder-spot wrasse	Labayan	2	6					**2**
Labridae	*Anampses neoguinaicus*	New guinea wrasse	Labayan	1	3					**1**
Mullidae	*Parupeneus multifasciatus*	Many-bar Goatfish	Saramulyete	10	4					**10**
Mullidae	*Parupeneus barberinus*	Dash-Dot Goatfish	Saramulyete	6	3					**6**

FISH ABUNDANCE DATA FORM										
Site Name: Across Barangays Uacon and Sinabacan				Municipality & Province: Candelaria, Zambales						
Date: June 06-07, 2018				Observers: Rowena R. Quimpo						
				Depth(m): 6-15 meters						
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126° - within Batong Lakay MPA									
	Station No. 2 (FVC2) - N 15.662158° E 119.923407° - within Sinabacan-Malimanga MPA									
	Station No. 3 (FVC3) - N 15.680567° E 119.932866° - area across Puerto del Mar Resort									
FAMILY	**SCIENTIFIC NAME**	**COMMON NAME**	**LOCAL NAME**	**Station 1**		**Station 2**		**Station 3**		**Total # of indivi-duals**
				# of ind	**Size (cm)**	**# of ind**	**Size *(cm)***	**# of ind**	**Size *(cm)***	
Nemipteridae	*Pentapodus bifasciatus*	White-shouldered whiptail	Silay, Ubod	15	10	3	8			**18**
Pomacentridae	*Dascyllus trimaculatus*	Three-spotted Damselfish	Bika-bika	20	3					**20**
Pomacentridae	*Abudefduf sexfasciatus*	Scissortail sergeant	Kapal	30	4					**30**
Pomacentridae	*Abudefduf vaigensis*	Indo-Pacific Sergeant	Kapal	25	5					**25**
Pomacentridae	*Amblyglyphidodon curacao*	Staghorn damselfish	Palata	60	3			8	3	**68**
Pomacentridae	*Amblyglyphidodon leucogaster*	Yellow-belly damselfish	Palata	6	8	15	3			**21**
Pomacentridae	*Neoglyphidodon oxyodon*	Bluestreak damselfish	Palata	4	8					**4**

FISH ABUNDANCE DATA FORM										
Site Name: Across Barangays Uacon and Sinabacan				Municipality & Province: Candelaria, Zambales						
Date: June 06-07, 2018				Observers: Rowena R. Quimpo						
				Depth(m): 6-15 meters						
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126° - within Batong Lakay MPA									
	Station No. 2 (FVC2) - N 15.662158° E 119.923407° - within Sinabacan-Malimanga MPA									
	Station No. 3 (FVC3) - N 15.680567° E 119.932866° - area across Puerto del Mar Resort									
FAMILY	**SCIENTIFIC NAME**	**COMMON NAME**	**LOCAL NAME**	**Station 1**		**Station 2**		**Station 3**		**Total # of indivi-duals**
				# of ind	**Size (cm)**	**# of ind**	**Size *(cm)***	**# of ind**	**Size *(cm)***	
Pomacentridae	*Dascyllus reticulatus*	Reticulated dascyllus	Palata	8	5					**8**
Pomacentridae	*Dischistodus pseudochrysopoecilus*	Monarch damsel	Palata	4	3	3	5			**7**
Pomacentridae	*Chromis margaritifer*	Bicolor chromis	Palata	2	6					**2**
Scaridae	*Chlorurus bleekeri*	Bleeker's parrotfish	Mul-mol	6	10			15	6	**21**
Scaridae	*Scarus ghobban*	Blue-barred parrotfish	Mul-mol	15	8	10	6			**25**
Scaridae	*Scarus niger*	Dusky parrotfish	Mul-mol	12	6			8	4	**20**
Siganidae	*Siganus vulpinus*	Foxface rabbitfish	Tag-bago, Samaral	3	9			6	4	**9**

FISH ABUNDANCE DATA FORM										
Site Name: Across Barangays Uacon and Sinabacan				Municipality & Province: Candelaria, Zambales						
Date: June 06-07, 2018				Observers: Rowena R. Quimpo						
				Depth(m): 6-15 meters						
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126° - within Batong Lakay MPA									
	Station No. 2 (FVC2) - N 15.662158° E 119.923407° - within Sinabacan-Malimanga MPA									
	Station No. 3 (FVC3) - N 15.680567° E 119.932866° - area across Puerto del Mar Resort									
FAMILY	**SCIENTIFIC NAME**	**COMMON NAME**	**LOCAL NAME**	**Station 1**		**Station 2**		**Station 3**		**Total # of indivi-duals**
				# of ind	**Size (cm)**	**# of ind**	**Size *(cm)***	**# of ind**	**Size *(cm)***	
Serranidae	*Cephalopholis cyanostigma*	Blue-spotted grouper	Lapu-lapu, Ulpot	4	8			2	6	**6**
Serranidae	*Epinephelus areolatus*	Areolate grouper	Lapu-lapu, Ulpot			2	14			**2**
Synodontidae	*Synodus dermatogenys*	Clearfin Lizardfish	Tiki-tiki	3	10					**3**
Tetraodontidae	*Canthigaster solandri*	Spotted Sharpnose	Butete					2	12	**2**
Zanclidae	*Zanclus cornutus*	Moorish Idol	Saguranding	4	10	1	4	3	6	**8**
Total # of individuals per transect (500m²)				**365**		**59**		**64**		**488**
Species Richness										

FISH ABUNDANCE DATA FORM										
Site Name: Across Barangays Uacon and Sinabacan				Municipality & Province: Candelaria, Zambales						
Date: June 06-07, 2018				Observers: Rowena R. Quimpo						
				Depth(m): 6-15 meters						
Location Coordinates	**Station No. 1 (FVC1)** - N 15.650878° E 119.916126° - within Batong Lakay MPA									
	Station No. 2 (FVC2) - N 15.662158° E 119.923407° - within Sinabacan-Malimanga MPA									
	Station No. 3 (FVC3) - N 15.680567° E 119.932866° - area across Puerto del Mar Resort									
FAMILY	**SCIENTIFIC NAME**	**COMMON NAME**	**LOCAL NAME**	**Station 1**		**Station 2**		**Station 3**		**Total # of indivi-duals**
				# of ind	**Size (cm)**	**# of ind**	**Size *(cm)***	**# of ind**	**Size *(cm)***	
Total number of fish families										**14**
Total number of target species▪										**23**
Total number of indicators										**8**
Total number of other species										**15**
Total number of species										**46**

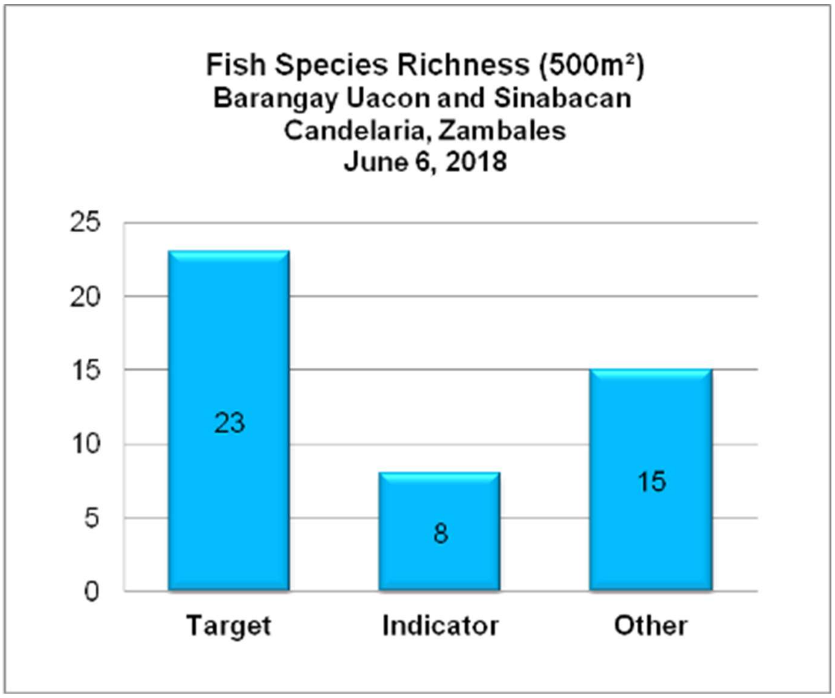


Figure 98 - Fish species richness per standard fish category catalogued in three FVC stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-07 June 2018

In view of their relative abundance, target fish species had a higher density per square meter in 500m^2 of survey corridor, registering at 0.46 fish/m^2. Fish species in the 'Other' category registered a density of 0.402 fish/m^2/500m^2 survey area while density of indicator species was computed at 0.078 fish/m^2/500m^2 survey area (*Figure 99*).

Accordingly, fish biomass is highest amongst target species, estimated at 1.64 kg per 500 m^2. Biomass for indicator and 'other' species was computed at 0.30 and 1.68 kg per 500m^2, respectively (*Figure 100*). In spite of the presence of dense fish recruits, especially in station 1 (Batong Lakay MPA), the productivity, in terms of fish biomass for target species, is relatively low.

The salient findings of the FVC survey in three stations is displayed in *Figure 101.*

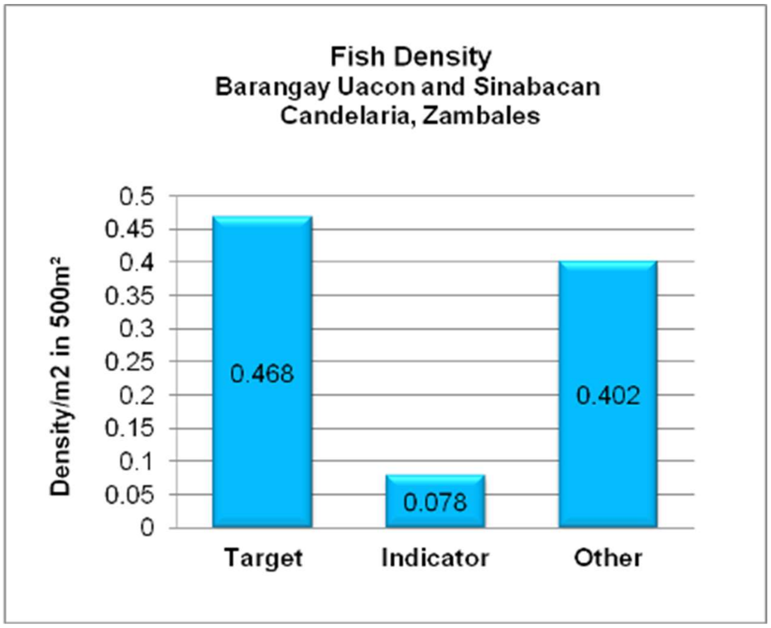


Figure 99 - ***Fish density by standard fish category catalogued in three FVC stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-07 June 2018***

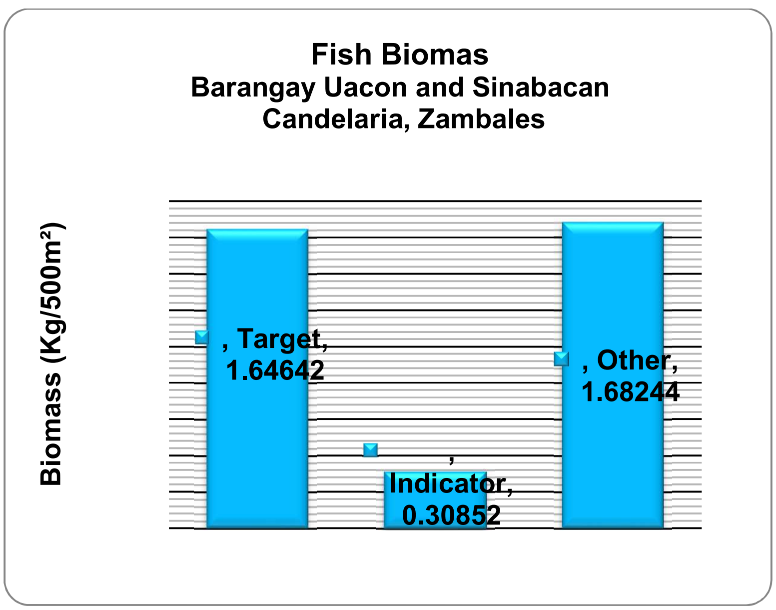


Figure 100 - Fish biomass per standard fish category catalogued in three FVC stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; 06-07 June 2

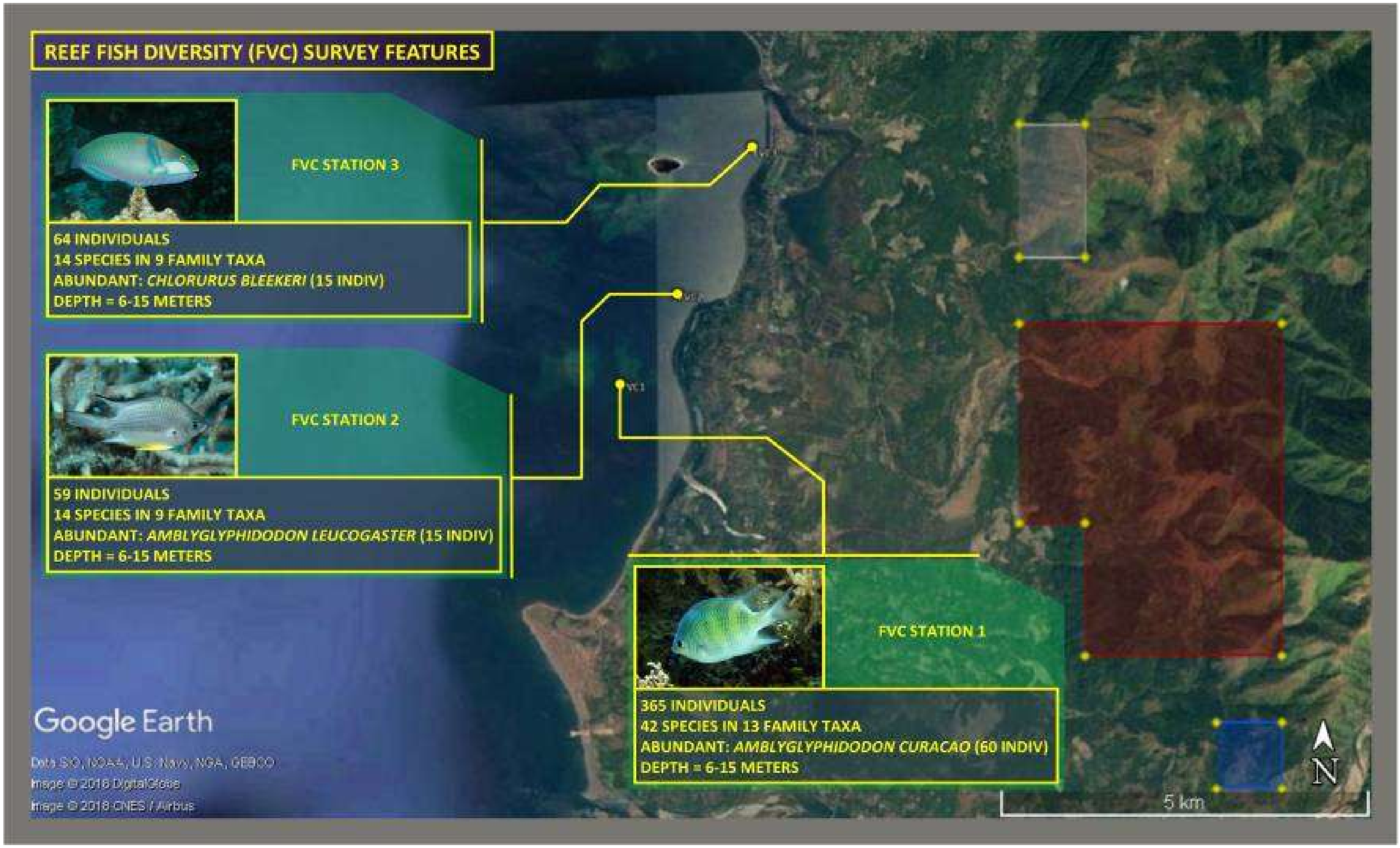


Figure 101 - Highlights of results of fish visual census for species richness and abundance in three FVC stations surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; June 2018

2.2.4.5.6 Fisheries – results of actual fishing documentation

In three days of surveys in relatively calm seas, no significant fishing operation by local fishers was observed. Key informants claim that nearshore fisheries productivity has declined considerably with diminishing catch composition diversity and catch rates as well as sizes of fish (*personal interview with 3 fishers*). Thus, fishermen with bigger boats venture out to open waters of the West Philippine Sea. The main fishing grounds are offshore shoals in the West Philippine sea. The coral reefs around the project site used to be productive fishing grounds but the use of dynamite and cyanide in fishing operations in the 1980s have resulted to the loss of coastal habitats and the demersal fish population that are normally dependent on healthy reefs. Observations from fish visual census reveal that the present reef flats in Baranbgay Uacon and Sinabacan hosts little target species- mostly surgeonfishes, fusiliers and juvenile emperor fish. Hook and line fishing gears are used for offshore fishing while simple handlines andsurface gill nets are used in nearshore waters to catch small pelagic such as scads and mackerels. Multiple hooks are used to capture the fusiliers and rabbitfishes in degrade reef flats. Offshore fishing target large pelagic species such as Tuna, Marlins, Spanish Mackerel, Dolphinfish and large barracudas, employing fish aggregating devices (*Table 70*). The common catch rate ranges from 10 to 30 kilograms per fishing trip that last at least 8 hours but the distance – 4 hours trip to offshore fishing grounds, is a deterent. Information from key respondents indicates that catch per unit effort in nearshore areas close to the shoreline is less than 1.5 kilograms per fisher per day. Productivity is therefore very low.

Table 70 - List of commonly caught fish species in nearshore and offshore waters ofCandelaria, Zambales (marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; 06-08 June 2018.

English name	Local common name (Navotas terminology)	Scientific name
Japanese mackerel	Alumahan	*Scomber australasicus*
Rainbow runner	Salmon	*Elagatis bipinulatus*
Spanish mackerel	Tanguinge	*Scomberomorus commerson*
Barracuda	Torcillo	*Sphyraena spp*
Siganids	Samaral	*Siganus spp*
Skipkack Tuna	Golyasan	*Katsuwonus pelamis*
Wrasse	Molmol	*Labridae*
Emperors	Bisugo	*Lethrinus spp*
Dolphinfish	Dorado	*Coryphaena hipporus*
Frigate mackerel	Tulingan	*Auxis thazard*
Short bodied mackerel	Hasa-hasa	*Rastrelliger brachysoma*
Roundscad	Galungong	*Decapterus macrosoma*
Sailfish	Malasugui	*Istiophorus platypterus*
Longtaill Tuna	Bariles	*Thunnus tonggol*

One of two actual fishing documentations involved a couple pulling drive-in net to capture milkfish fry. In three hours of operation, about 4000 fry were harvested with an estimated value of PhP 1,600.00. The capture of milkfish fry is seasonal and harvesting is normally done during a full moon. The second actual fishing documentation was in Barangay Uacon where three fishers using simple hook and line were encountered in shallow waters above a degraded reef flat. The CPUE is low – 2.5 kg of small fishes in six hours fishing time, or only 0.4 kilogram every hour. The catch composition consisted mostly of Nemiptreids (Bisugo), wrasses and a triggerfish (Plate 8).

The highlights of findings from actual fishing documentation are shown in *Figure 102.*


Plate 31 - ***Actual fishing operations encountered during the marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales in June 2018: left photo- two fishers catching milkfish fry; and right photo - catch of 3 hook and line fishers in 6 hours operation include mostly threadfin breams (Bisugo Nemipterus japonicus) and wrasses.***

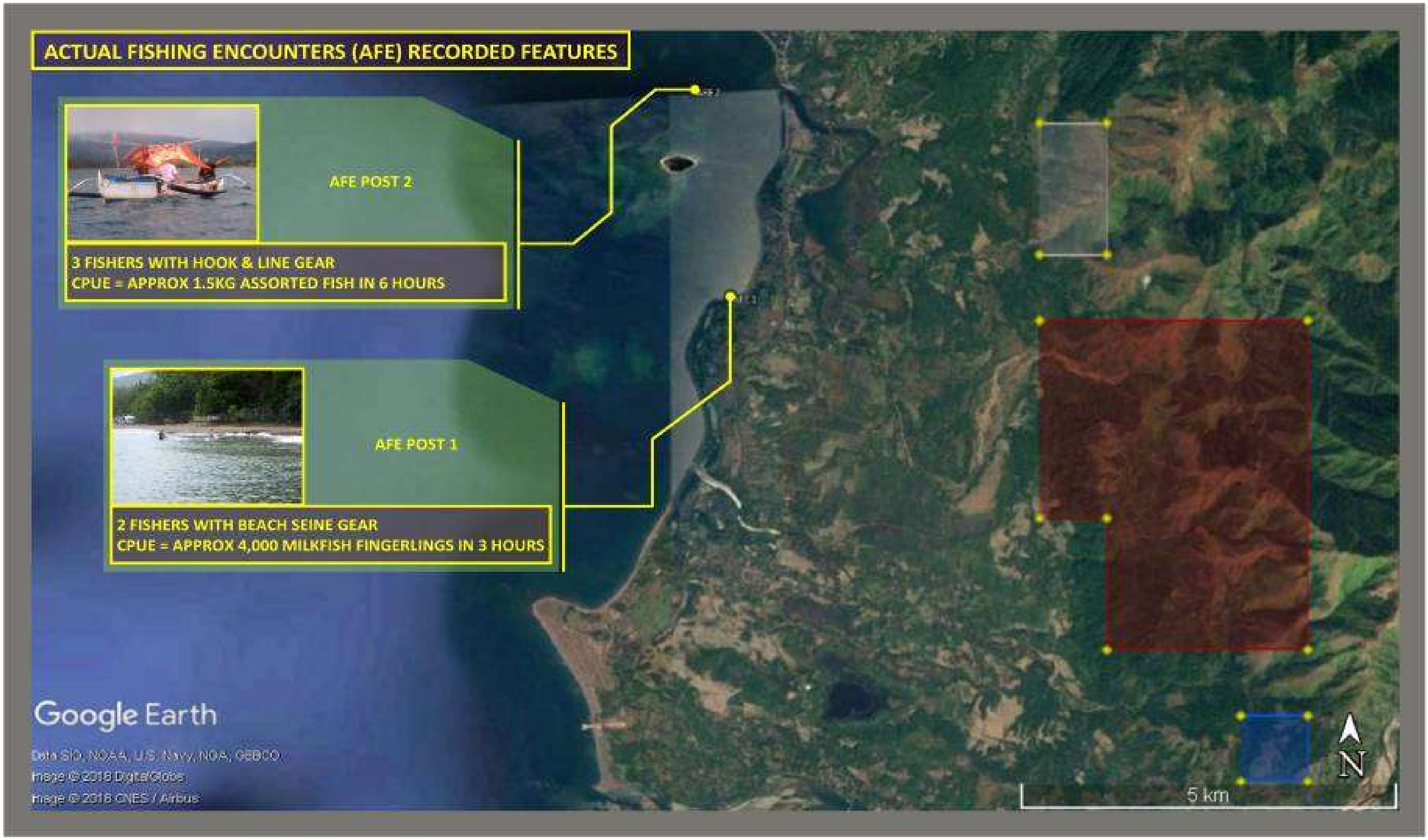


Figure 102 - Highlights of documented actual fishing operations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Project in Candelaria, Zambales; June 2018

2.2.4.5.7 Result of assessment of sea grass communities

Extensive systematic snorkeling and observations from 47 manta tows failed to locate any significant seagrass meadows in front of the nearshore shelf in five coastal Barangays in the coaastal impact area of the proposed nickel mining project. In a report of the BFAR in 2009 in line with the formulation of the Candelaria Integrated Coastal Resource Management Plan (ICRM), seagrass assessment showed that seagrass locally known as "baliba" only thrives within Brgy. Uacon where four species were found: eel seagrass (*Enhalus acoroides*), sickle seagrass (*Thalassia hemprichii*), needle seagrass (*Halodule uninervis*) and the tube seagrass *Syringodium isoetifolium.* During the 2018 survey, fishers claimed that patches of seagrass in the nearshore shelf of Barangay Uacon have been overcome with silt and sediments. A single intact meadow was eventually detected northwest of Potipot Island where one transect was laid out in turbid waters.

Results of the assessment, summarized in
Table 71 and shown in *Figure 103*, show four (4) segarass species dominated by *Cymodecea rotundata* (ribbon seagrass) – a species which was not mentioned in the 2009 report of the BFAR, and *Thalassia hempricii* (sickle seagrass), covering 20% and 21% of the total seagrass meadow surveyed, respectively. The two other seagrass species are *Syringodium isoetifolium* (tube seagrass) and *Halophila ovalis* (spoon seagrass), accounting for 4% of the seagrass community combined (*Figure 103; Plate 32*). The later species, *H. ovalis*, was also not encountered in the previous report for the ICRM Plan. The seagrass were growing intermittently, as sand and rocks were prominent, covering more than half of the transect area (54.5%). Apart from 2 specimens of the ball sea urchin (*Tripnuestes gratilla*) and a carapace of the spider shell (*Lambis sp*) encountered in the seagrass transect, no significant community of macro-invertebrates or holothurians were seen in the seagrass meadow.

Table 71 - Distribution of seagrass by species and percentage cover in one sampling station located close to Isla de Potipot, Barangay Uacon, in Candelaria, Zambales, during the marine

ecology baseline assessment (MEBA); June 6, 2018. (Observers: Victor L. Pantaleon and Ronald T. Pocon).

Site Name: Waters along Isla de Potipot, Barangay Uacon			**Municipality & Province:** Candelaria, Zambales Province
Date: June 6, 2018			**Observers:** Victor L. Pantaleon and Ronald T. Pocon
Location:	Transect/Station 1 (SGR1) - Start: N 15.679570° E 119.919669°; End: N 15.679882° E 119.919342°		
Transect No.	**Seagrass Distribution**		**Remarks/Observation**
	Species	**Percent Cover** *(in % of total)*	
1	*Cymodocea rotundata*	20.00	38.50% sand, 16% rock; siltation with dissolved nutrients as contributed by river runoff or enhanced heavy rainfall, reducing water clarity in the survey station.
	Thalassia hemprichii	21.50	
	Syringodium isoetifolium	3.00	
	Halophila ovalis	1.00	
AVERAGE PERCENTILE		**45.50**	**Good cover/condition.**

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

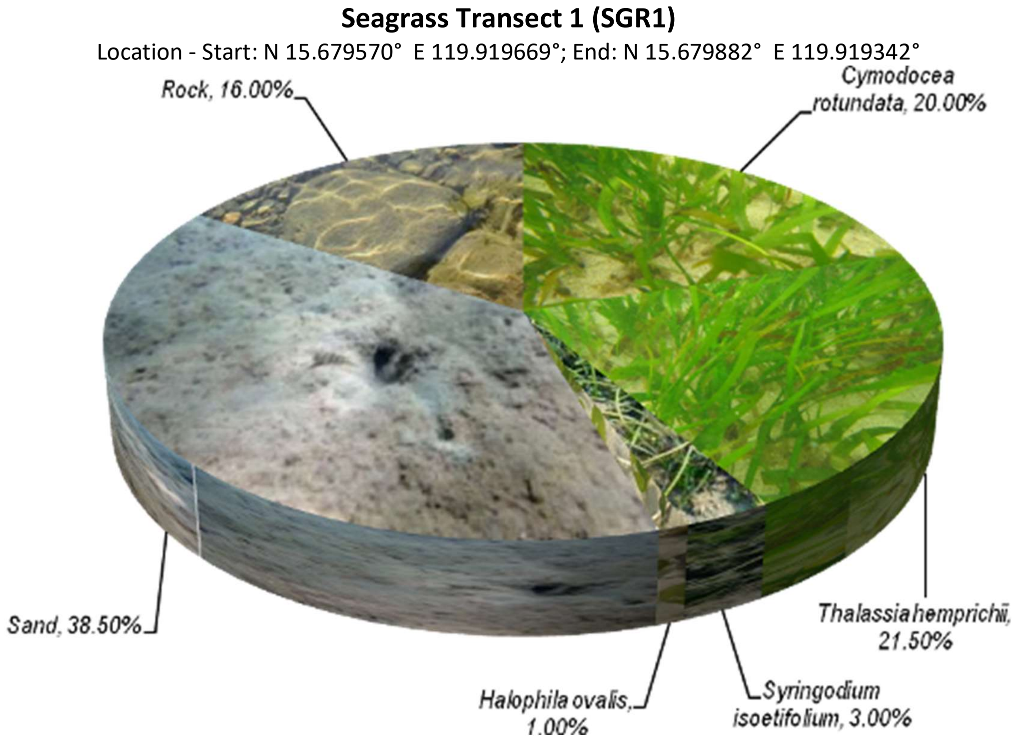


Figure 103 - Relative distribution of seagrass species in one sampling station for the Marine Ecology Baseline Assessment (MEBA) survey proximal to Isla de Potipot, Barangay Uacon, in Candelaria, Zambales; June 6, 2018; (Observers: Victor L. Pantaleon and Ronald T. Pocon).

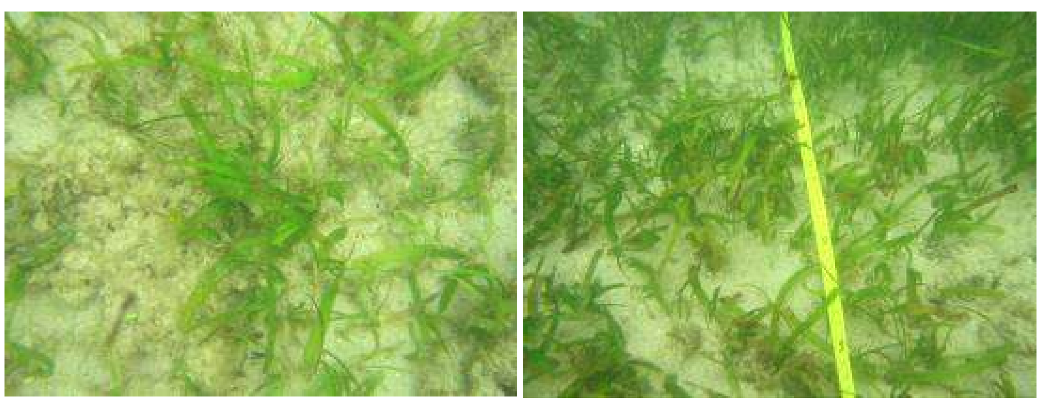


Plate 32 - ***Seagrass meadow surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChniaMin Nickel Project in Cadelaria, Zambales; 06 June 2018.***

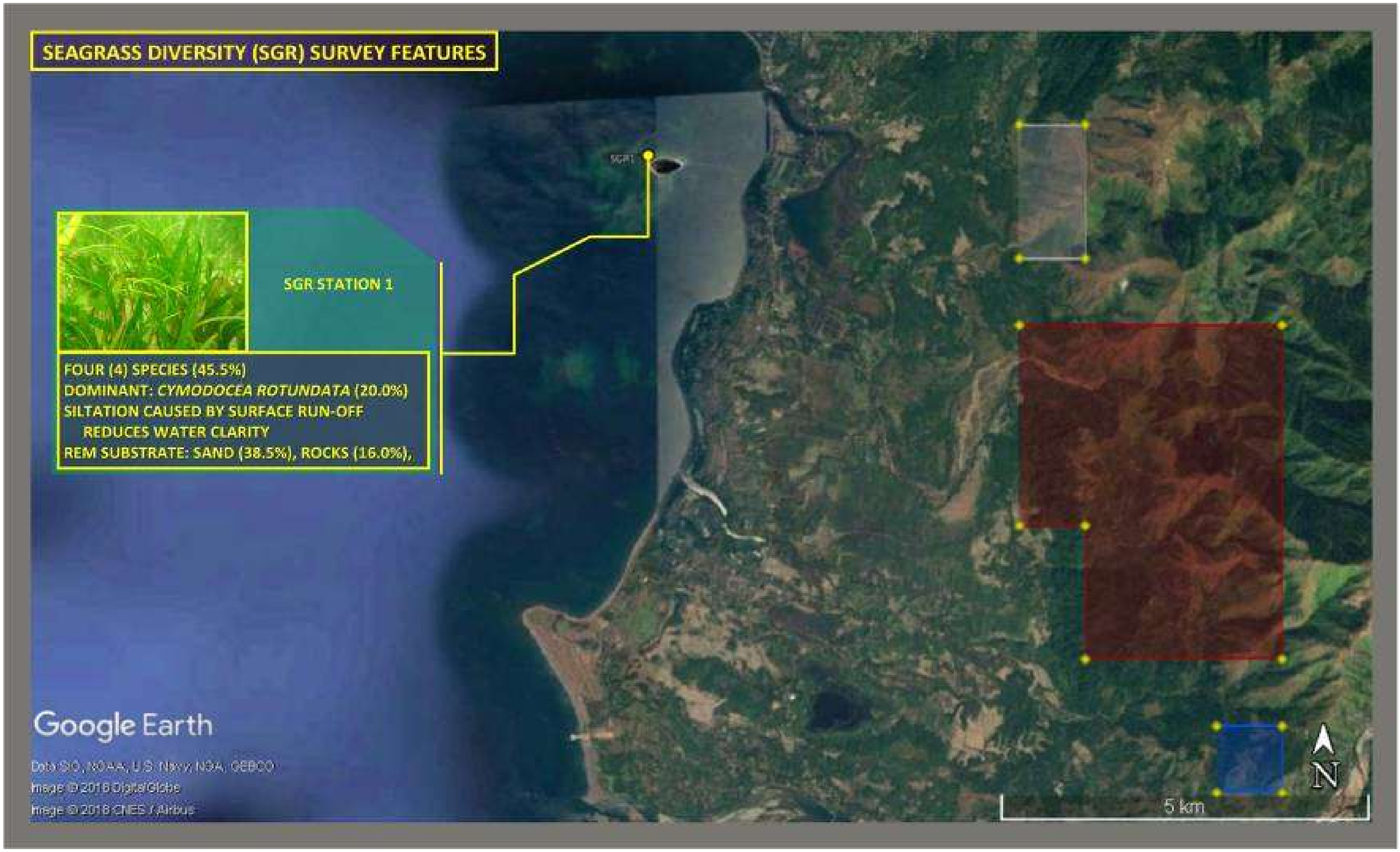


Figure 104 - Summary of results of seagrass assessment in one sampling station during the Marine Ecology Baseline Assessment (MEBA) survey proximal to Isla de Potipot, Barangay Uacon, in Candelaria, Zambales; June 6, 2018; (Observers: Victor L. Pantaleon and Ronald T. Pocon; map prepared by Jose Rene Villegas).

2.2.4.5.8 Results of mangrove assessment

The 2009 survey conducted by the DENR for the ICRM Plan of Candelaria reported that six (6) out of eight (8) coastal barangays of Candelaria have mangrove resources in varying extents. According to the mangrove assessment conducted by DENR (2009), good conditions of mangroves were observed in barangays of Binabalian, Panayonan and Uacon while fair condition of mangroves were seen in barangays of Malabon, Malimanga and Sinabacan. A fair condition denotes mangrove trees that have moderate disturbance and noticeable cuttings while good condition indicates slight disturbance and few cuttings.

Assessment results further showed that 17 mangrove species are found in the municipality where predominant ones being Bakauan-lalaki (*Rhizophora apiculata*), Pagatpat *(Sonneratiaalba)*, and Tinduk-tindukan *(Aegiceras floridum)*. The total number of trees is 1,917, with Bakauan-lalaki as the most dominant comprising about 40.22% of all trees recorded.

The marine ecology mangrove survey in 2018 recorded a total of 164 trees (75%), 24 seedlings (11%) and 30 (14%) saplings in four (4) quadrats in three (3) transects (Figure 29). There were a total of eight (8) species seen in the survey stations (*Figure 105*); and three more species were observed outside of the survey quadrats.

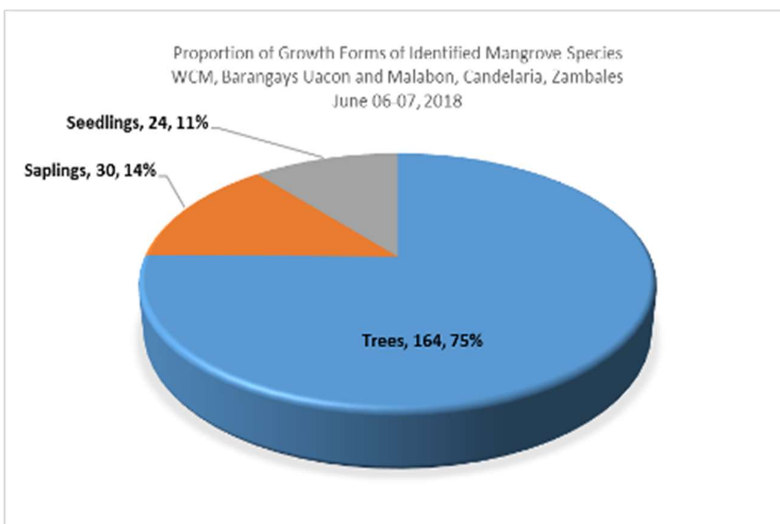


Figure 105 -Summary of results of mangrove survey in three transects during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

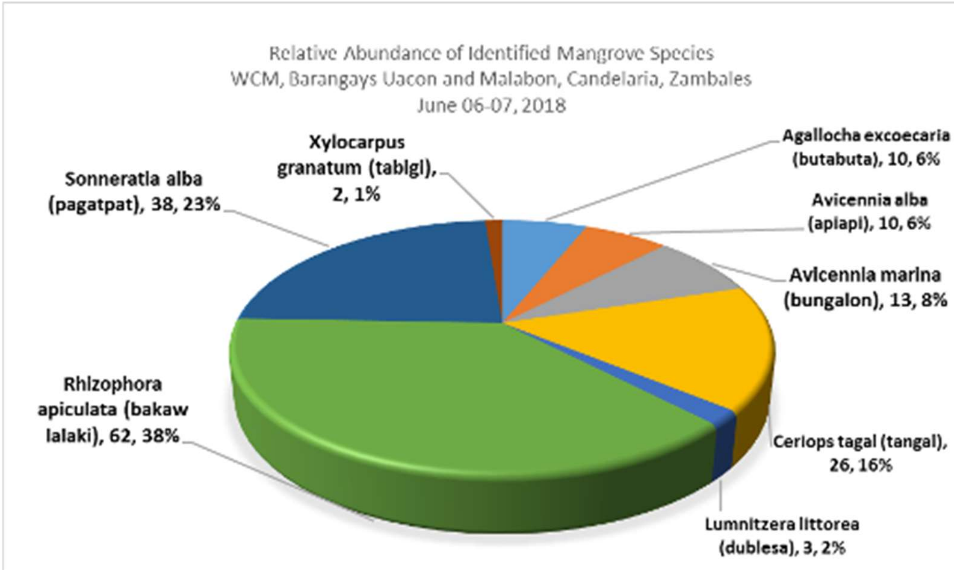


Figure 106 - Relative abundance of mangrove trees surveyed in three transects during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

Across the three stations, the mangroves were dominated by *Rhizopora apiculata* (bakaw lalaki), accounting for 38% of the community catalogued in the survey. This is followed by *Sonneratia alba* (pagatpat) comprising 23% of the trees, and *Ceriops tagal* (tangal). The rest of the species is comprised of *Avicennia marina* (bungalon, 8%), *Avicennia alba* (api-api, 6%), *Agallocha exoecaria* (buta-buta, 6%), *Lumnitzera littorea* (dublesa, 2%) and *Xylocarpus granatum*

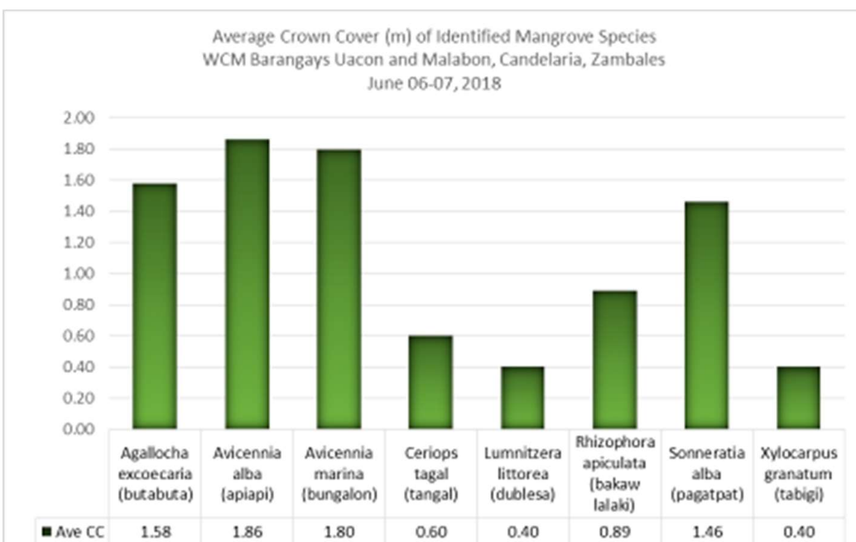


Figure 107 - Average mangrove crown cover by species across three stations surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

Average crown cover range from 0.40 m for *Xylocarpus granatum* and *Lumnitzera littorrea* to 0.86 meters for *Avicennia alba* species indicating Fair growth . The overall coran cover, recorde at 47% translates to Fair condition. Average tree height ranged from 4 meters for *Xylocarpus sp*, to 9 and 9.15 meters for *Avicennia* species. The overall mangrove tree height – at 7.43 meters, indicate excellent growth.

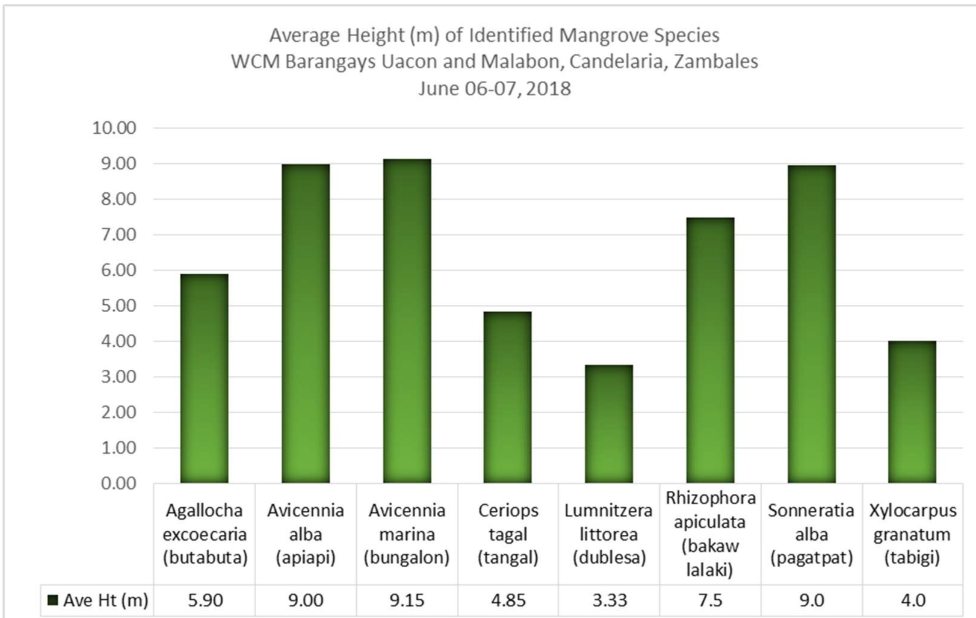


Figure 108 - *Average mangrove tree height by species recorded in three stations surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018*

A total of 94 mangrove trees were catalogued in two quadrats in Transect 1 in the eastern corner of Uacon Lake, accounting for 57% of the total community surveyed. The dominant tree species growing in the area is *Rhizophora apiculata* comprising 60.6 % of the total number of trees surveyed in the two (2) quadrants (94) followed by *Sonneratia alba* with 30.8 %, *Avicennia alba* and *Lumnitzera littorea* both with 3.2 % and *Xylocarpus granatum* 2.2%. The average Diameter in Breast Height (DBH) of *Sonneratia alba* with 48 centimeters and *Rhizophora apiculata* with 32 centimeters suggests old growth of these species in the area. Other mangrove species observed growing along the banks were, *Excoecaria agallocha*, *Heritiera littoralis, Bruguiera sp*. and *Nypa fruticans.*

Crown cover of mangroves in this transect was recorded at 48 % (Fair condition), average tree height at 7.3 m per tree indicating excellent growth, and a regeneration capacity of 0.88 seedlings and saplings per square meter (Good). *Sonneratia alba* and *Rhizopora apiculata* dominated mangrove crown cover. Moreover, *Sonneratia alba* dominated tree height with an average of 9.2 meters per tree.

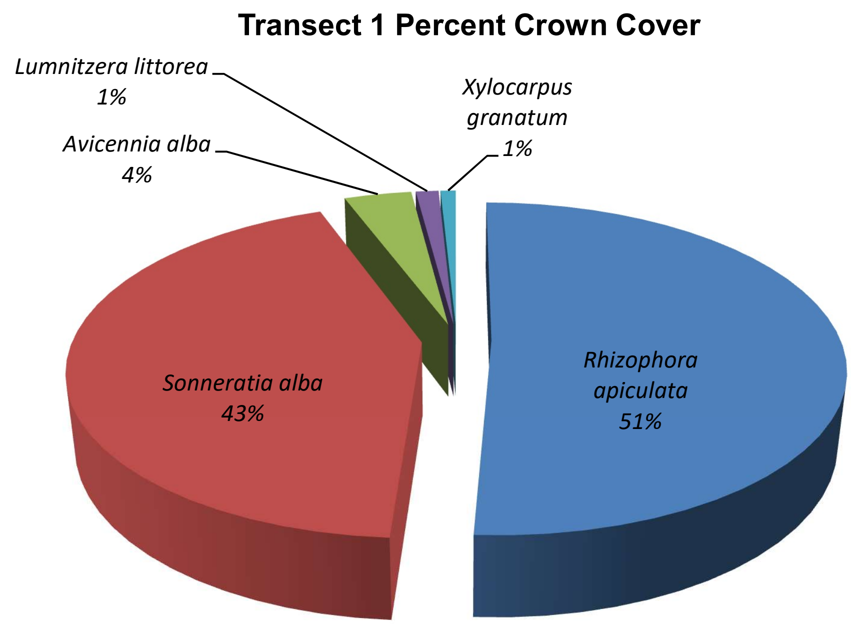


Figure 109 - Average crown cover of mangrove species in Transect 1 surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

Table 72 - Tabulated quantitative summary of mangrove trees surveyed in Transect 1, Bgy Uacon, Candelaria, Zambales during marine ecology baseline assessment – ChinaMin Nickel Project; June 2018

Mangrove Habitat Assessment Data Sheet –Transect 1							
Location: Uacon Lake, Barangay Uacon Candelaria, Zambales				MGV1 Location Coordinates:			
Observers: Benjamin Francisco and Ernie P. Fontamillas				N 15.665680° E 119.939740°			
Date of Survey: June 6, 2018							
Transect 1 - Quadrat 1							
Tree #	*Species*	Ht. (m)	Crown Diameter (m)				Observations
			Reading 1	Reading 2	Ave.	C. Cover	
1	*Sonneratia alba (pagatpat)*	7	2	1	1.5	1.18	

2	*Sonneratia alba (pagatpat)*	8	3	2	2.5	1.98	Substrate is ankle-deep, brownish color mud
3	*Sonneratia alba (pagatpat)*	8	3	1	2	1.58	
4	*Sonneratia alba (pagatpat)*	7	2	2	2	1.58	
5	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
6	*Rhizophora apiculata (bakaw lalaki)*	9	2	1	2	1.58	Seedlings; *R. apiculata* (1)
7	*Sonneratia alba (pagatpat)*	10	3	1	2	1.58	
8	*Sonneratia alba (pagatpat)*	8	2	1	1.5	1.18	
9	*Rhizophora apiculata (bakaw lalaki)*	8	2	1	1.5	1.18	
10	*Rhizophora apiculata (bakaw lalaki)*	7	1	1	1	0.79	
11	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	Saplings: *R. apiculata* (1)
12	*Rhizophora apiculata (bakaw lalaki)*	9	1	1	1	0.79	
13	*Rhizophora apiculata (bakaw lalaki)*	9	2	1	1.5	1.18	
14	*Rhizophora apiculata (bakaw lalaki)*	8	2	1	1.5	1.18	
15	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
16	*Rhizophora apiculata (bakaw lalaki)*	7	1	0.5	0.75	0.59	
17	*Rhizophora apiculata (bakaw lalaki)*	9	2	1	1.5	1.18	
18	*Sonneratia alba (pagatpat)*	10	3	2	2.5	1.98	
19	*Sonneratia alba (pagatpat)*	12	3	2	2.5	1.98	
20	*Rhizophora apiculata (bakaw lalaki)*	5	1	0.5	0.75	0.59	
21	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	
22	*Rhizophora apiculata (bakaw lalaki)*	6	1	1	1	0.79	
23	*Rhizophora apiculata (bakaw lalaki)*	7	1	0.5	0.75	0.59	
24	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
25	*Rhizophora apiculata (bakaw lalaki)*	7	1	1	1	0.79	
26	*Rhizophora apiculata (bakaw lalaki)*	7	2	0.5	1.25	0.99	
27	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	
28	*Rhizophora apiculata (bakaw lalaki)*	6	1	1	1	0.79	
29	*Rhizophora apiculata (bakaw lalaki)*	7	1	0.5	0.75	0.59	

30	*Rhizophora apiculata (bakaw lalaki)*	5	0.5	0.5	0.5	0.40	
31	*Rhizophora apiculata (bakaw lalaki)*	8	2	0.5	1.25	0.99	
32	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
33	*Rhizophora apiculata (bakaw lalaki)*	9	1	1	1	0.79	
34	*Rhizophora apiculata (bakaw lalaki)*	9	1.5	1	1.25	0.99	
35	*Sonneratia alba (pagatpat)*	10	2	2	2	1.58	
36	*Sonneratia alba (pagatpat)*	7	2	0.5	1.25	0.99	
37	*Sonneratia alba (pagatpat)*	11	3	1	2	1.58	
38	*Sonneratia alba (pagatpat)*	8	1	1	1	0.79	
39	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
40	*Rhizophora apiculata (bakaw lalaki)*	7	1	0.5	0.75	0.59	
41	*Rhizophora apiculata (bakaw lalaki)*	5	0.5	0.5	0.5	0.40	
42	*Avicennia alba (apiapi)*	9	2	1	1.5	1.18	
43	*Avicennia alba (apiapi)*	8	2	2	2	1.58	
44	*Avicennia alba (apiapi)*	9	1	1	1	0.79	
45	*Lumnitzera littorea (dublesa)*	3	0.5	0.5	0.5	0.40	
46	*Lumnitzera littorea (dublesa)*	4	0.5	0.5	0.5	0.40	
47	*Lumnitzera littorea (dublesa)*	3	0.5	0.5	0.5	0.40	
48	*Sonneratia alba (pagatpat)*	10	2	1	1.5	1.18	
49	*Sonneratia alba (pagatpat)*	10	3	1	2	1.58	
50	*Sonneratia alba (pagatpat)*	8	2	1	1.5	1.18	
51	*Sonneratia alba (pagatpat)*	5	1	1	1	0.79	
Sub Total 51		Sub Total 389				Sub Total 51.14	Seedlings = 1 Saplings = 1

Transect 1 – Quadrat 2

Tree #	*Species*	Ht (m)	Crown Diameter (m)				Observations
			Reading1	Reading2	Ave.	C.Cover	

1	*Sonneratia alba (pagatpat)*	10	2	1	1.5	1.18	
2	*Sonneratia alba (pagatpat)*	10	2	1	1.5	1.18	Seedlings:
3	*Rhizophora apiculata (bakaw lalaki)*	5	1	0.5	0.75	0.59	*R. apiculata* (2)
4	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	
5	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	Saplings:
6	*Rhizophora apiculata (bakaw lalaki)*	5	1	0.5	0.75	0.59	*R. apiculata* (1)
7	*Rhizophora apiculata (bakaw lalaki)*	7	2	1	1.5	1.18	
8	*Rhizophora apiculata (bakaw lalaki)*	7	1	1	1	0.79	
9	*Rhizophora apiculata (bakaw lalaki)*	6	1	1	1	0.79	
10	*Rhizophora apiculata (bakaw lalaki)*	9	2	1	1.5	1.18	
11	*Rhizophora apiculata (bakaw lalaki)*	10	2	2	2	1.58	
12	*Rhizophora apiculata (bakaw lalaki)*	9	2	1	1.5	1.18	
13	*Xylocarpus granatum (tabigi)*	3	0.5	0.5	0.5	0.40	
14	*Xylocarpus granatum (tabigi)*	5	0.5	0.5	0.5	0.40	
15	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	
16	*Rhizophora apiculata (bakaw lalaki)*	9	1	1	1	0.79	
17	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
18	*Sonneratia alba (pagatpat)*	10	2	1	1.5	1.18	
19	*Sonneratia alba (pagatpat)*	11	3	2	2.5	1.98	
20	*Sonneratia alba (pagatpat)*	10	2	1	1.5	1.18	
21	*Sonneratia alba (pagatpat)*	9	3	1	2	1.58	
22	*Sonneratia alba (pagatpat)*	8	2	0.5	1.25	0.99	
23	*Rhizophora apiculata (bakaw lalaki)*	12	2	2	2	1.58	
24	*Rhizophora apiculata (bakaw lalaki)*	10	3	2	2.5	1.98	
25	*Rhizophora apiculata (bakaw lalaki)*	10	2	1	1.5	1.18	
26	*Rhizophora apiculata (bakaw lalaki)*	12	3	1	2	1.58	
27	*Rhizophora apiculata (bakaw lalaki)*	8	2	1	1.5	1.18	
28	*Rhizophora apiculata (bakaw lalaki)*	8	1	0.5	0.75	0.59	

29	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	
30	*Rhizophora apiculata (bakaw lalaki)*	9	2	1	1.5	1.18	
31	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
32	*Sonneratia alba (pagatpat)*	10	2	2	2	1.58	
33	*Sonneratia alba (pagatpat)*	12	3	2	2.5	1.98	
34	*Sonneratia alba (pagatpat)*	10	2	1	1.5	1.18	
35	*Sonneratia alba (pagatpat)*	10	3	1	2	1.58	
36	*Sonneratia alba (pagatpat)*	9	2	1	1.5	1.18	
37	*Sonneratia alba (pagatpat)*	10	3	2	2.5	1.98	
38	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	
39	*Rhizophora apiculata (bakaw lalaki)*	8	1	0.5	0.75	0.59	
40	*Rhizophora apiculata (bakaw lalaki)*	8	0.5	0.5	0.5	0.40	
41	*Rhizophora apiculata (bakaw lalaki)*	8	1	1	1	0.79	
42	*Rhizophora apiculata (bakaw lalaki)*	7	0.5	0.5	0.5	0.40	
43	*Rhizophora apiculata (bakaw lalaki)*	6	1	0.5	0.75	0.59	
Sub Total 43		356				44.79	Seedlings = 2 Saplings = 1
Over-all Total 94		**Overall Total 745**				**Overall Total 95.93**	**Regeneration:** **Seedlings = 3** **Saplings = 2**

Table 73 - Mangrove assessment in Transect 1 - summary and evaluation for crown cover, tree height and regeneration capacity.

Percent Crown Cover	95.93 CC/200m² area X 100	48 %	**Fair**
Average Tree Height	745 mtrs. Total Ht. / 94 total trees	7.93 m / tree	**Excellent**
Regeneration (Seedlings & Saplings)	5 ss / 6 m² (6 plots @ 3 plots per quadrant with 1 m² / plot)	0.8 ss / m²	**Good**

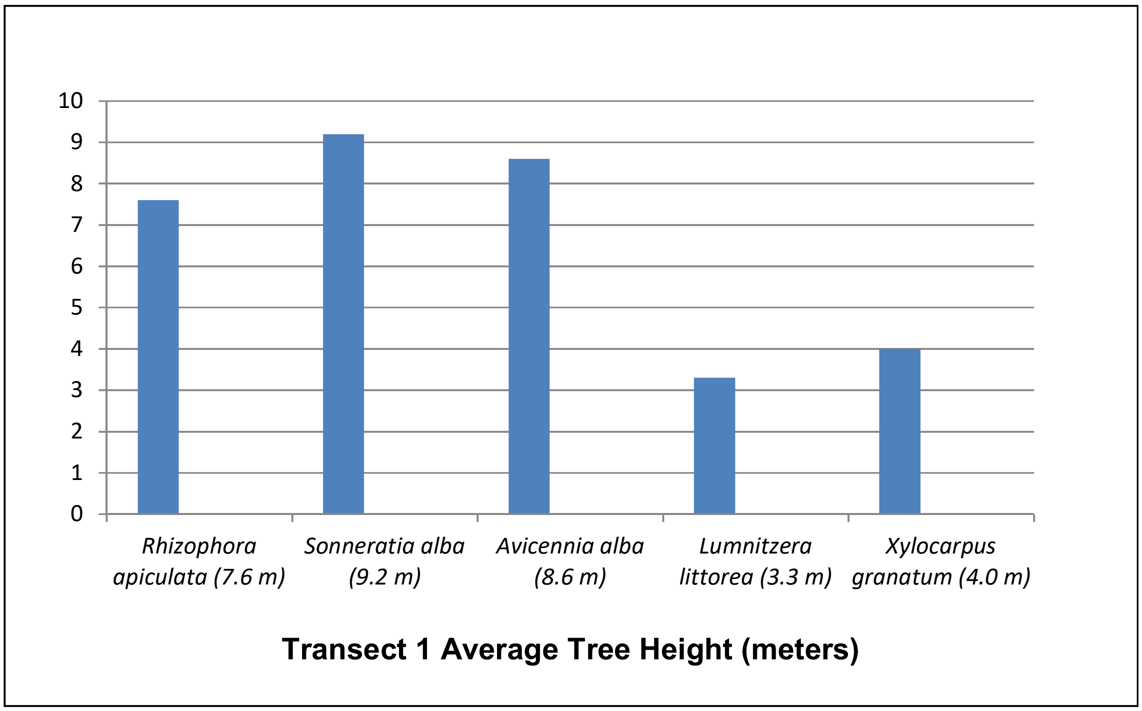


Figure 110 - Average tree height of mangrove species in Transect 1 surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

In Transect 2, a total of forty (40) trees were recorded with six (6) mangrove species dominated by *Sonneratia alba (12% of the community)* and *Avicennia marina (14%)*. The area surveyed was fringing growth of mangroves 10 meters wide along the river bank. *Avicennia marina* that measures an average of 87 centimeters Diameter in Breast Height (DBH) and *Sonneratia alba* with 56 centimeters DBH suggest old growth. It was noticeable that although the area is surrounded by domestic houses there is no mangrove cuttings observed.

Table 74 - Tabulated quantitative summary of mangrove trees surveyed in Transect 2, Bgy Malabon, Candelaria, Zambales during marine ecology baseline assessment – ChinaMin Nickel Project; June 2018.

Mangrove Habitat Assessment Data Sheet – Transect 2	
Location: Malabon River, Bgy Malabon, Candelaria, Zambales	**MGV2 Location Coordinates:**
Observers: Benjamin Francisco and Ernie P. Fontamillas	**N 15.635510° E 119.929400°**
Date of Survey: June 6, 2018	

Transect 2 - Quadrat 1

Tree #	*Species*	Ht. (m)	Crown Diameter (m)				Observations
			Reading1	Reading2	Ave.	C.Cover	
1	*Avicennia marina (bungalon)*	10	3	2	2.5	1.98	Substrate is knee-deep, black color mud
2	*Avicennia marina (bungalon)*	12	3	3	3	2.37	
3	*Avicennia marina (bungalon)*	12	3	2	2.5	1.98	
4	*Avicennia marina (bungalon)*	10	3	2	2.5	1.98	
5	*Avicennia marina (bungalon)*	9	2	1	1.5	1.19	Seedlings;*R. apiculata* (8)
6	*Avicennia marina (bungalon)*	9	2	2	2	1.58	
7	*Avicennia marina (bungalon)*	8	2	1	1.5	1.19	*C. tagal* (6)
8	*Avicennia marina (bungalon)*	10	3	1	2	1.58	
9	*Sonneratia alba (pagatpat)*	12	3	3	3	2.37	
10	*Sonneratia alba (pagatpat)*	10	3	1	2	1.58	
11	*Sonneratia alba (pagatpat)*	8	2	1	1.5	1.19	Saplings:
12	*Sonneratia alba (pagatpat)*	8	2	2	2	1.58	*C. tagal* (12)
13	*Sonneratia alba (pagatpat)*	7	2	2	2	1.58	*R. apiculata* (3)
14	*Sonneratia alba (pagatpat)*	7	3	1	2	1.58	*A. alba* (5)
15	*Sonneratia alba (pagatpat)*	8	3	2	2.5	1.98	
16	*Avicennia alba (apiapi)*	8	3	1	2	1.58	
17	*Avicennia alba (apiapi)*	10	3	2	2.5	1.98	

18	*Avicennia alba (apiapi)*	10	2	2	2	1.58	
19	*Ceriops tagal (tangal)*	6	1	1	1	0.79	
20	*Ceriops tagal (tangal)*	6	1	0.5	0.75	0.59	
21	*Ceriops tagal (tangal)*	5	1	1	1	0.79	
22	*Ceriops tagal (tangal)*	6	1	0.5	0.75	0.59	
23	*Ceriops tagal (tangal)*	6	1	0.5	0.75	0.59	
24	*Ceriops tagal (tangal)*	5	1	1	1	0.79	
25	*Ceriops tagal (tangal)*	5	1	0.5	0.75	0.59	
26	*Ceriops tagal (tangal)*	4	1	0.5	0.75	0.59	
27	*Ceriops tagal (tangal)*	4	0.5	0.5	0.5	0.40	
28	*Ceriops tagal (tangal)*	6	1	0.5	0.75	0.59	
29	*Ceriops tagal (tangal)*	6	1	1	1	0.79	
30	*Ceriops tagal (tangal)*	5	0.5	0.5	0.5	0.40	
31	*Ceriops tagal (tangal)*	4	0.5	0.5	0.5	0.40	
32	*Ceriops tagal (tangal)*	3	0.5	0.5	0.5	0.40	
33	*Ceriops tagal (tangal)*	4	1	0.5	0.75	0.59	
34	*Rhizophora apiculata (bakaw lalaki)*	5	2	1	1.5	1.19	
35	*Rhizophora apiculata (bakaw lalaki)*	6	2	1	1.5	1.19	
36	*Rhizophora apiculata (bakaw lalaki)*	6	1	1	1	0.79	
37	*Sonneratia alba (pagatpat)*	5	1	1	1	0.79	
38	*Sonneratia alba (pagatpat)*	8	2	1	1.5	1.19	
39	*Rhizophora apiculata (bakaw lalaki)*	7	2	2	2	1.58	
40	*Rhizophora apiculata (bakaw lalaki)*	8	3	1	2	1.58	
Sub Total 40		Sub Total				SubTotal48 .05	Seedlings = 14

		288						Saplings = 20
Overall Total 40		**Overall Total 288**					**Overall Total 48.05**	**Regeneration: Seedlings = 14 Saplings = 20**

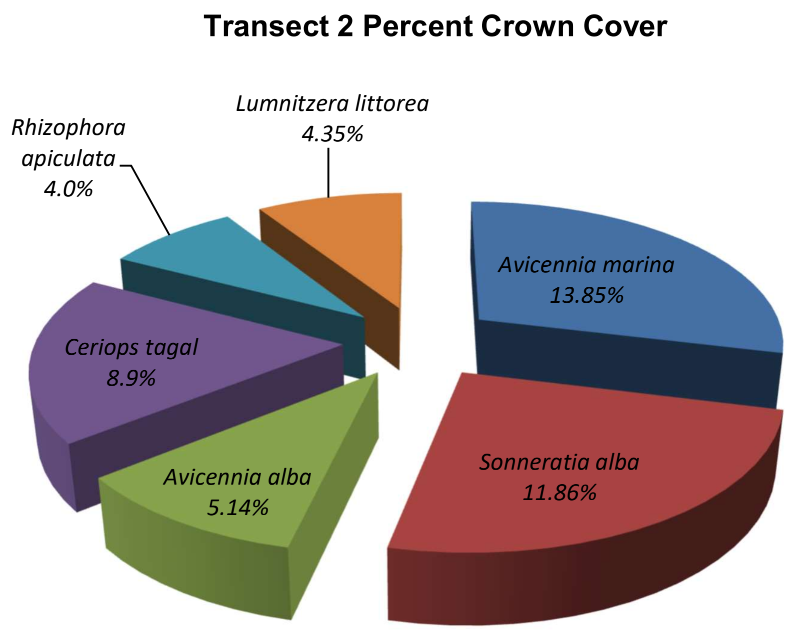


Figure 35. Average crown cover of mangrove species in Transect 2 (Bgy Malabon) surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

The average crown cover of mangroves in station 2 was recorded at 48%, indicating "Fair Condition" in standard mangrove forest rating. Crown cover was greatest with *Avicennia sp* and *Sonneratia sp,* with a combined canopy of 25.7 %. Across the transect, average crown cover was recorded at 48.5% (Fair Condition), average tree heigth at 7.2 meters (Excellent;) and regeneration capacity of 11.3 seedlings/saplings per square meter (Excellent;). *Avicennia sp* and *Sonneratia sp* also dominated tree heigth, measuring 8.6 to 10 meters indicating presence of old growth trees.

Table 75 - Mangrove assessment in Transect 2 - summary and evaluation for crown cover, tree height and regeneration capacity.

Percent Crown Cover	48.05 total Crown Cover / 100m² x 100	48.05 %	**Fair**
Average Tree Height	288 mtrs. total height/ 40 pcs. total no. of trees	7.2 meters	**Excellent**
Regeneration (Seedlings & Saplings)	34 ss / 3 m² (3 plots with 1 m² / plot)	11.3 ss/m²	**Excellent**

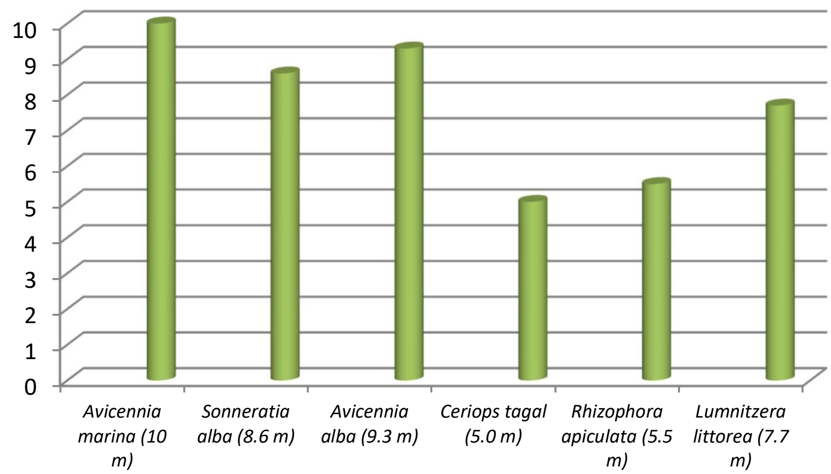


Figure 111 - Average tree height of mangrove species in Transect 2 surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

Transect 3 yielded a total of thirty (30) trees in the transect, owing to the thin strip of mangroves in the banks of the Malabon River. Moreover, concrete flood control revetments have caused drying up of some portions of the mangroves fringing the river. The area surveyed has old growth of *Avicennia alba* with 208 centimeters Diameter at Breast Height (DBH) and *Sonneratia alba* with 58 centimeters DBH. There is abundant growth of *Agallocha excoecaria* in the area due to its sandy-mud substratum. However, propagules of *Rhizophora sp.* though abundant in the area may not be able to grow robustly due to the nature of the substrate and reduced inflow of seawater in some portions of the mangrove due to the establishment of concrete flood control structures.

Plate 33 - Mangroves in the Malabon River with flood control revetment in the foreground (left); and in Uacon Lake (right).

Across Transect 3 in the banks of the Malabon River, the average crown cover was computed at 42% (Fair Condition) with *Agallocha exoecaria* and *Avicennia alba* dominating the canopy (Figure 36). Average tree height was documented at an average of 6.16 meters while regeneration capacity was recorded at 5 seedlings/saplings/m^2.

Table 76 - Tabulate quantitative summary of mangrove trees surveyed in Transect 3, Bgy Malabon, Candelaria, Zambales during marine ecology baseline assessment – ChinaMin Nickel Project; June 2018.

Mangrove Habitat Assessment Data Sheet - Transect 3, Candelaria, Zambales							
Location: Malabon River, Bgy Malabon, Candelaria, Zambales				**MGV3 Location Coordinates:**			
Observers: Benjamin Francisco and Ernie P. Fontamillas				**N 15.631460° E 119.937420°**			
Date of Survey: June 7, 2018							
Transect 3 - Quadrat 1							
Tree #	***Species***	**Ht. (m)**	**Crown Diameter (m)**				**Observations**
			Reading1	Reading2	Ave.	C.Cover	
1	*Avicennia alba (apiapi)*	10	4	2	3	2.37	Substrate is knee-deep, black color mud
2	*Avicennia alba (apiapi)*	10	5	3	4	3.16	
3	*Avicennia alba (apiapi)*	8	3	3	3	2.37	
4	*Avicennia alba (apiapi)*	8	3	2	2.5	1.98	
5	*Agallocha excoecaria (butabuta)*	6	3	1	2	1.58	

6	*Agallocha excoecaria (butabuta)*	6	2	2	2	1.58	Seedlings;
7	*Agallocha excoecaria (butabuta)*	5	2	2	2	1.58	*R. apiculata* (3)
8	*Agallocha excoecaria (butabuta)*	6	3	1	2	1.58	*C. tagal* (4)
9	*Agallocha excoecaria (butabuta)*	6	3	2	2.5	1.98	
10	*Agallocha excoecaria (butabuta)*	7	2	2	2	1.58	
11	*Agallocha excoecaria (butabuta)*	6	3	1	2	1.58	
12	*Agallocha excoecaria (butabuta)*	6	2	2	2	1.58	Saplings:
13	*Agallocha excoecaria (butabuta)*	5	2	1	1.5	1.19	*C. tagal* (5)
14	*Agallocha excoecaria (butabuta)*	6	3	1	2	1.58	*R. apiculata* (2)
15	*Ceriops tagal (tangal)*	4	1	0.5	0.75	0.59	*A. alba* (1)
16	*Ceriops tagal (tangal)*	5	1	1	1	0.79	
17	*Ceriops tagal (tangal)*	5	1	0.5	0.75	0.59	Abundant growth of *Nypa fruticans* and *Acrostichum* sp.
18	*Ceriops tagal (tangal)*	4	1	1	1	0.79	
19	*Ceriops tagal (tangal)*	4	1	0.5	0.75	0.59	
20	*Ceriops tagal (tangal)*	6	1	1	1	0.79	
21	*Ceriops tagal (tangal)*	5	1	0.5	0.75	0.59	
22	*Ceriops tagal (tangal)*	4	0.5	0.5	0.5	0.40	
23	*Ceriops tagal (tangal)*	4	0.5	0.5	0.5	0.40	
24	*Ceriops tagal (tangal)*	5	1	0.5	0.75	0.59	
25	*Ceriops tagal (tangal)*	5	1	0.5	0.75	0.59	
26	*Avicennia marina (bungalon)*	8	3	2	2.5	1.98	
27	*Avicennia marina (bungalon)*	7	3	2	2.5	1.98	
28	*Avicennia marina (bungalon)*	8	3	1	2	1.58	
29	*Avicennia marina (bungalon)*	9	3	3	3	2.37	
30	*Avicennia marina (bungalon)*	7	3	1	2	1.58	
Sub Total 30		Sub Total 185				SubTotal4 1.89	Seedlings = 7 Saplings = 8
Overall Total		**Overal l Total**				**Overall Total**	**Regeneration: Seedlings = 7**

30		**185**				**41.89**	**Saplings = 8**

Percent Crown Cover	41.89 total CC / 100 m² x 100	41.89 %	**Fair**
Average Tree Height	185 meters. total height / 30 no. of trees	6.16 meters	**Excellent**
Regeneration (Seedlings & Saplings)	15 ss / 3 m² (3 plots with 1 m² / plot)	5 ss / m²	**Excellent**

Table 20. Summary of mangrove assessment findings in Transect 3 – Candelaria, Zambales

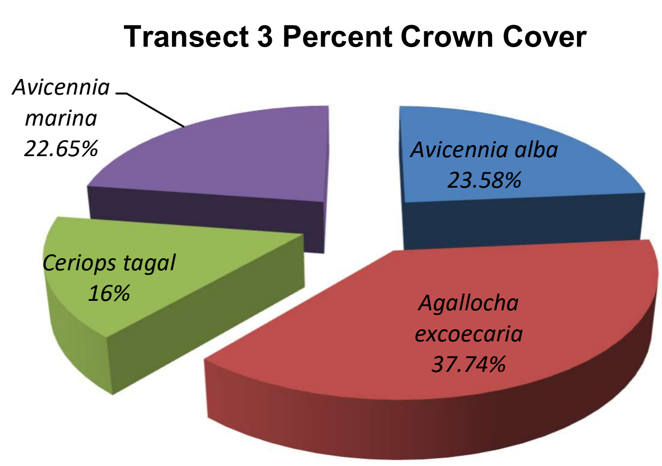


Figure 112 - Average crown cover of mangrove species in Transect 3 (Bgy Malabon) surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

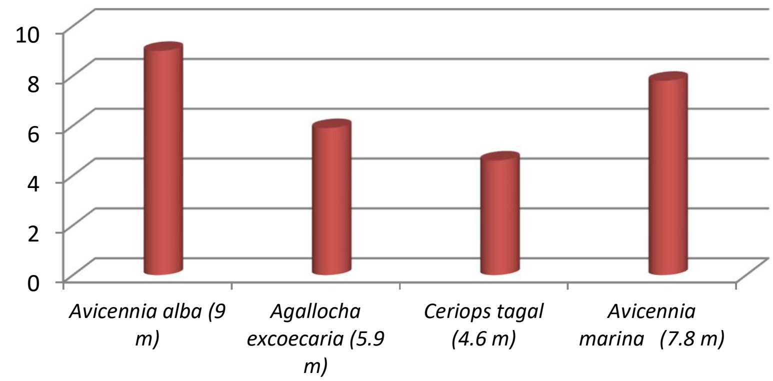


Figure 113 - Average tree height of mangrove species in Transect 3 surveyed during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018

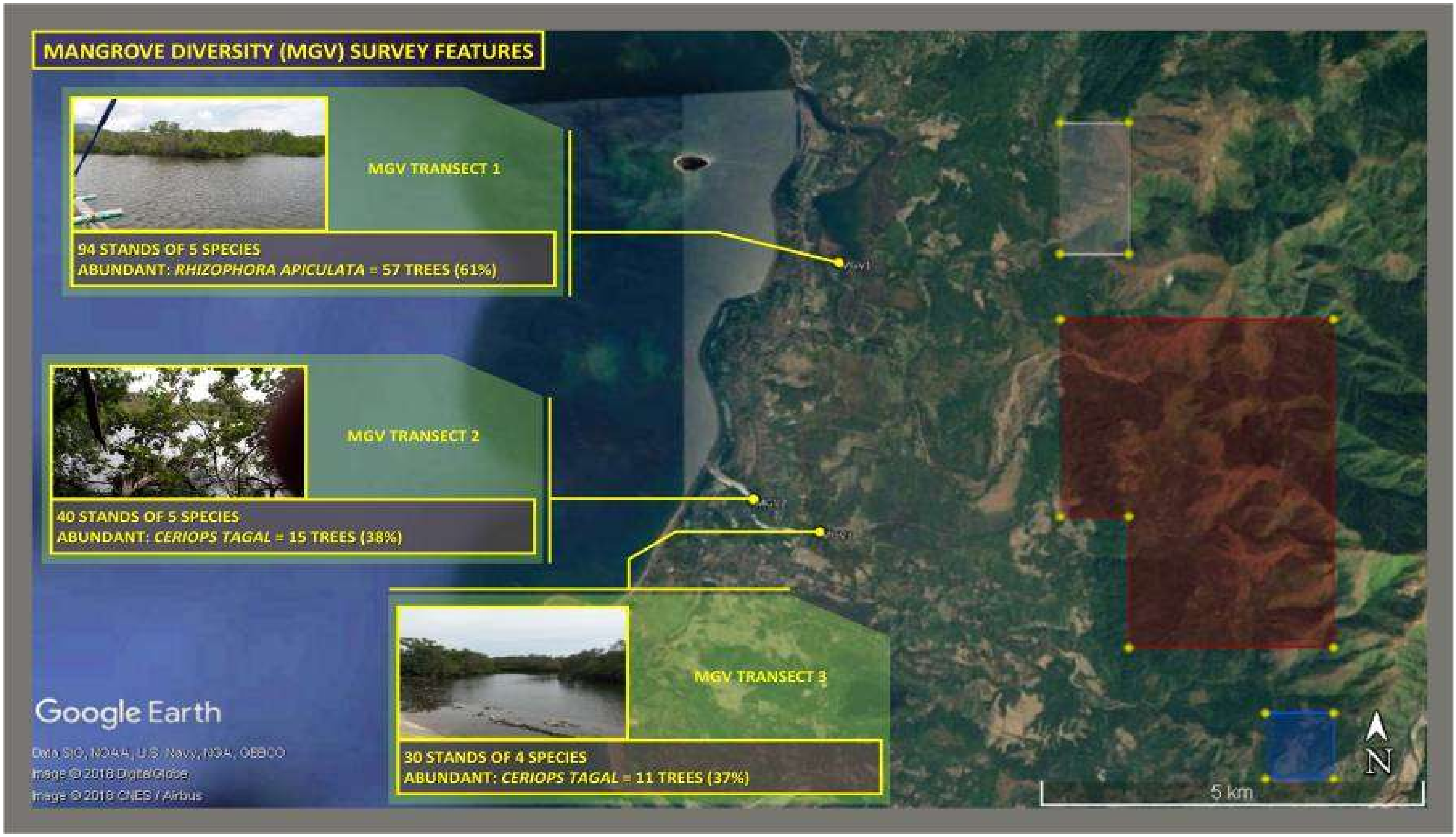


Figure 114 - Salient findings of mangrove survey in three stations during marine ecology baseline assessment in the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; 06 June 2018; (map prepared by Jose Rene Villegas).

2.2.4.5.9 Plankton

2.2.4.5.9.1 Phytoplankton Diversity

The phytoplankton community diversity, abundance, and relative composition were determined at four sampling stations (PLK1-PLK4) in pre-set locations by GIS along the marine waters offshore from the coastline of Candelaria Town to assess and compare the microscopic biota located within as a primary impact area of the WESTCHINAMIN Mining Project in Candelaria – Zambales on 06 June 2018.

Results of laboratory analysis revealed a total density of 897,921 cells/L belonging to 31 genera and certain species that were identified for all sampling stations. The phytoplankton community in the survey area is comprised of organisms from three major phytoplankton taxa: Cyanophytes (blue-green algae) with a single genera, Bacillariophytes (diatoms) with 17 genera, and Dinophytes (dinoflagellates) with 13 representations (= 7 genera and 6 species) .

Diatoms were the most abundant taxonomic group with a total count of 741,799 cells/L accounting for 82.6% composition, while the dinoflagellates had 67,375 cells/L at 7.5% composition, and blue-green algae with 88,747 cells/L at 9.9% composition (Table 21 and Figure 38). The centric, chain forming diatom, *Chaetoceros* spp. was the most abundant with a total sampling count of 577,495 cells/L accounting for 64.3% composition for all recorded organisms. This genera is one of the most widespread and abundant diatom in marine and brackish habitats worldwide. These are usually found at a higher abundance than other species due to opportunistic behavior and a rapid response to nutrient pulses and water turbulence (Reynolds, 2006). Some studies suggest that colonies of *Chaetoceros* serve as an important food source within the water column and major carbon contributor to the benthic environment.

Other diatoms that contribute to the amassed volume of cells are *Rhizosolenia* spp. with 21,713 cells/L (2.42% of total composition) and *Pseudonitzschia* spp. with 32,837 cells/L (3.66% of the total composition).

For *Rhizosolenia* spp., this organism can also be found in marine and brackish water, while some species are also found in sediments. *Rhizosolenia* plays a significant role in the carbon, silica and nitrogen cycles in the oligotrophic seas. The increases of some species of *Rhizosolenia* are responsible for lowering the numbers of good phytoplankton in certain seas due to competition of nutrients. *Rhizosolenia* can also cause fish kills by clogging the gills with their hard silica exterior and from post-bloom anoxia. At the same time, live and dead cells of *Rhizosolenia* are used by bacteria and benthic animals for nutrients. Invertebrates cannot use them directly for nutrients because of the morphological structure of the cells. These two genera are also among the most frequently occurring phytoplankton in all sampling stations.

For *Pseudonitzschia* spp., some species of this genera are known to produce domoic acid (DA) – a toxin associated with Amnesic Shellfish Poisoning (ASP). Currently, 51 species are known, 26 of which have been shown to produced DA. The direct impacts of species identification on public health make this a serious concern. Toxogenic and nontoxogenic species commonly co-occur; therefore, discrimination between various *Pseudonitzschia* spp. is imperative to determine the potential toxicity of an algal bloom. Optical microscopy identification techniques are inadequate when a large number of samples must be routinely examined, such as is required for a monitoring program for public health. Unlike certain dinoflagellate blooms, domoic acid-producing *Pseudonitzschia* spp. must be present in high concentrations (greater than 100,000 cells L^{-1}) to contaminate shellfish at a level that would cease harvesting. Sediment cores indicate a link between increasing coastal nutrient levels (eutrophication) and an increase in *Pseudonitzschia* spp. blooms (ref: https://en.wikipedia.org/wiki/Pseudo-nitzschia).

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 source of filter-feeding shellfish, which are found along the coastal waters of the survey area.

The solitary blue-green algae, *Trichodesmium* spp. was determined to be the next abundant at a total of 88,747 cells/L (9.9% composition) that contributed to the total volume of identified phytoplankton. This genera is a common, filamentous, and bloom-forming organism which are significant in the marine ecosystem as it contributes more than 40% of all nitrogen-fixation processes occurring in the ocean (Karl, 2002). Cyanobacteria are also generally found at high densities in highly eutrophic water bodies.

For the dinoflagellates, the two dominant representatives are: *Diplosalis* spp. - the relatively most abundant in its taxonomic group with 12,484 cells/L (1.39% of total composition) and was found to occur in all sampling stations, followed by *Protoperidinium* spp. with 9,936 cells/L (1.11% of total composition).

A noteworthy species is *Ceratium fusus* having 6,965 cells/L (0.78% of total composition), which is also found in all sampling stations aside from the *Diplosalis* spp. dinoflagellate. The *Ceratium* genera are generally considered harmless and produce non-toxic chemicals. However, under certain conditions that promote rapid growth of the population, *Ceratium* sp. blooms can deplete the resources and nutrients of the surrounding environment, such as dissolved oxygen in the water, which results to fish kills (ref: https://en.wikipedia.org/wiki/Ceratium). However, the five species-specific of Ceratium genera recorded in the sampling may not be included to cause such blooms and are in low densities in the survey area.

These dinoflagellates play important roles at the base of the food web. They are sources of nutrients for larger organisms and also prey on smaller organisms such as diatoms.

The other potentially harmful phytoplankton organisms recorded in this survey is *Dinophysis caudata* with 7,785 cells/L (0.87% of total composition). Some species of this dinoflagellate are associated to produce toxins that cause Diarrheic Shellfish Poisoning (DSP). Cell densities however observed during the sampling was relatively low compared to areas where blooms of these organisms have been reported (Azanza and Taylor 2001).

For this survey, species identification of the mentioned genera was not feasible as it requires a more powerful microscope such as the Transmission Electron Microscope (TEM); moreover, there is no confirmed incidence of ASP and DSP reported in the Philippines, but for monitoring purposes, the presence of these organisms should not be taken for granted and ignored, and always be considered as potentially harmful. Their population should be systematically monitored on a regular basis during all project phases to prevent negative public health impact brought about by possible blooms of these species.

Photomicrographs of dominant and common phytoplankton found in the survey area are shown in Plates 11A to 11F.

Table 77 - Phytoplankton composition, abundance (cells/L), and diversity in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

TAXA	SAMPLING STATIONS				Grand	Rel
	PLK1	PLK2	PLK3	PLK4	Total	Abund
Blue-green Algae (1)	**56,900**	**11,465**	**14,013**	**6,369**	**88,747**	**9.88**
Trichodesmium	56,900	11,465	14,013	6,369	88,747	9.88
Diatoms (17)	**273,461**	**128,663**	**160,057**	**179,618**	**741,799**	**82.61**
Amphora		2,038	2,803	1,699	6,540	0.73
Asterionella	1,274			19,108	20,382	2.27
Bellorochea	425				425	0.05

TAXA	SAMPLING STATIONS				Grand	Rel
	PLK1	PLK2	PLK3	PLK4	Total	Abund
Chaetoceros	245,860	87,898	107,431	136,306	577,495	64.31
Climacosphenia			2,180	3,397	5,577	0.62
Coscinodiscus	5,096	3,057	1,246	4,671	14,070	1.57
Ditylum			1,557		1,557	0.17
Fragilaria		1,529	4,048		5,577	0.62
Hemiaulus	2,123	2,803	4,048	2,972	11,946	1.33
Licmophora			1,868		1,868	0.21
Navicula		3,312	2,491	4,671	10,474	1.17
Odontella	2,972	1,529	1,246	2,548	8,295	0.92
Pleurosigma	3,397				3,397	0.38
Pseudonitzschia	5,520	4,331	20,863	2,123	32,837	3.66
Rhizosolenia	2,123	14,268	4,048	1,274	21,713	2.42
Skeletonema		3,822	1,868		5,690	0.63
Thalassionema	4,671	4,076	4,360	849	13,956	1.55
Dinoflagellates (13)	**11,041**	**12,739**	**10,898**	**32,697**	**67,375**	**7.50**
Ceratium furca	849		4,048	849	5,746	0.64
Ceratium fusus	425	3,312	2,803	425	6,965	0.78
Ceratium macroceros			623	425	1,048	0.12
Ceratium trichoceros	1,274		311	849	2,434	0.27
Ceratium tripos	2,972		934	3,822	7,728	0.86
Ceratocorys	1,274			2,548	3,822	0.43
Dinophysis caudata		1,529	311	5,945	7,785	0.87
Diplopsalis	1,699	1,274	1,868	7,643	12,484	1.39
Goniodoma				2,123	2,123	0.24
Gyrodinium	425				425	0.05
Ornithocercus	1,274	3,057		1,699	6,030	0.67

TAXA	SAMPLING STATIONS				Grand	Rel
	PLK1	PLK2	PLK3	PLK4	Total	Abund
Protoperidinium	849	3,567		5,520	9,936	1.11
Pyrophacus				849	849	0.09
Total Abundance (N)	**341,402**	**152,867**	**184,968**	**218,684**	**897,921**	**100**
Mean Abundance = 224,480						
Total No. of Organisms = 31						
Richness	**20**	**17**	**22**	**24**		
Mean Richness = 21						
Diversity (H')	**1.08**	**1.74**	**1.73**	**1.69**		
Evenness (I')	**0.36**	**0.62**	**0.56**	**0.53**		

Note: Genera and associated values highlighted in red characters indicate a potential bio-toxin agent

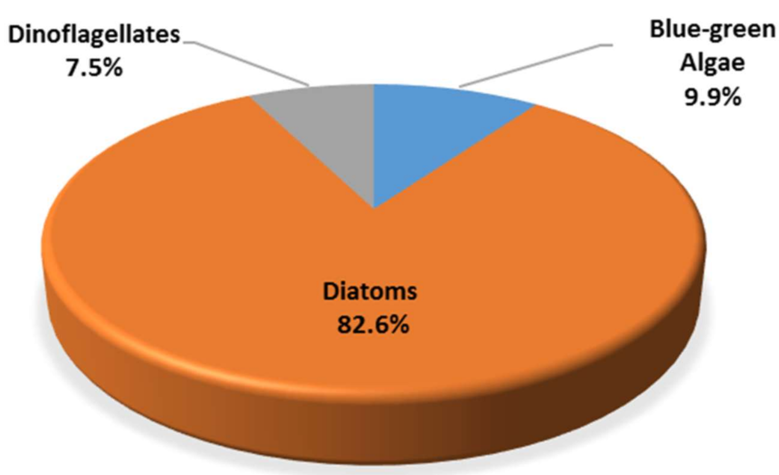


Figure 115 - Percentage composition of major phytoplankton groups in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

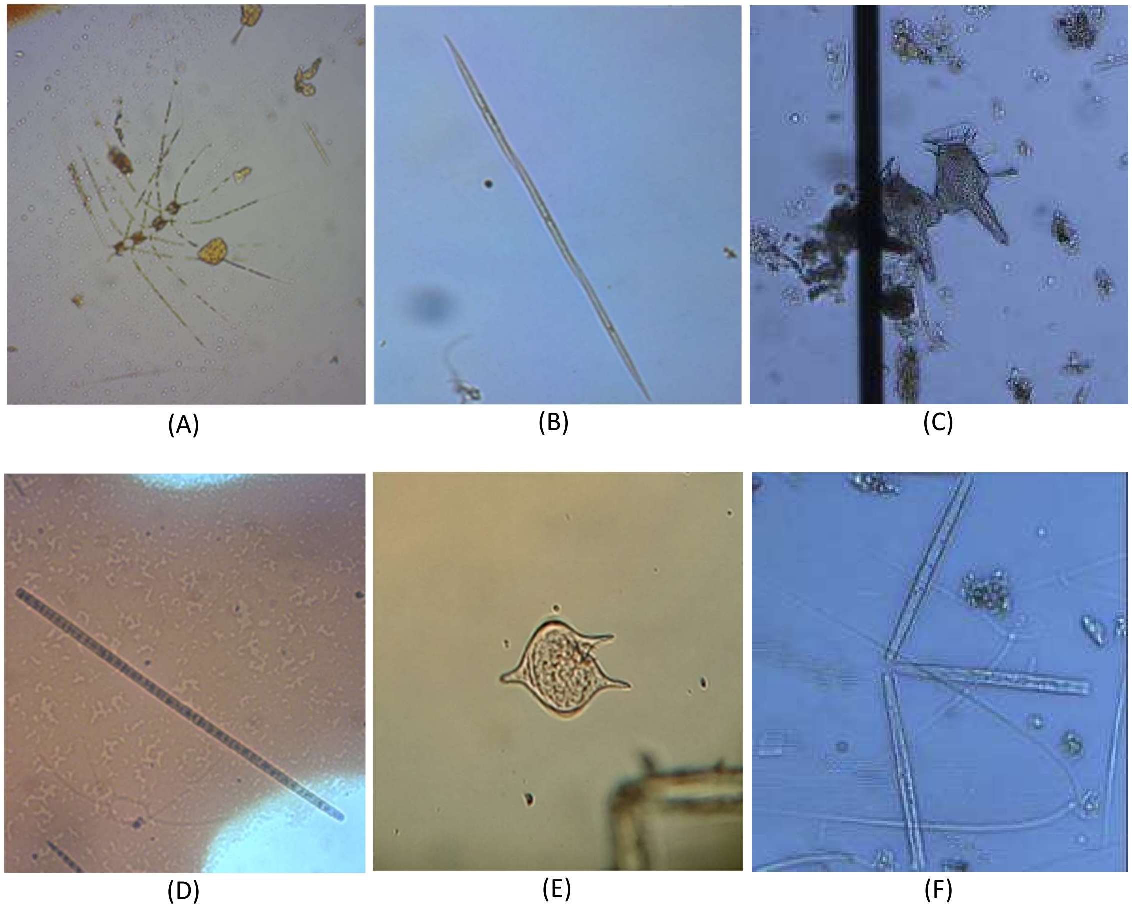


Plate 34 A-F - Photomicrographs of phytoplankton identified and recorded in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018. Top: (A) Chaetoceros spp. (B) Pseudonitzschia spp. (C) Dinophysis caudata spp.; Bottom: (D) Trichodesmium spp. (E) Protoperidinium spp. (F) Thalassionema spp.

The mean cell density of all phytoplankton in the four sampling stations during this sampling period was 224,480 cells/L. In terms of spatial distribution, sampling station PLK 1 had the highest abundance with 341,402 cells/L, while the relatively most taxa representation was in sampling station PLK4 with 24 genera out of the total 31 documented. Sampling station PLK1 is located proximal to the port of Candelaria and the outlet of the Lauis River while sampling station PLK4 is offshore from the Sinabacan-Manimanga Marine Protected Area.

In contrast, the relatively lowest phytoplankton density at 152,867 cells/L and the lowest taxa representation with 17 recorded organisms was attributed to sampling station PLK2, which is located offshore across from the outlet of the Malabon River. During this survey, all three taxa groups were recorded in all sampling stations, but the concentration of densities for the blue-green algae and diatoms were in sampling station PLK1, while the diatoms are concentrated in density in sampling station PLK4. In terms of abundance, all sampling stations were dominated by diatoms, particularly by Chaetoceros spp., which is the most numerous genera of all recorded organisms as previously discussed.

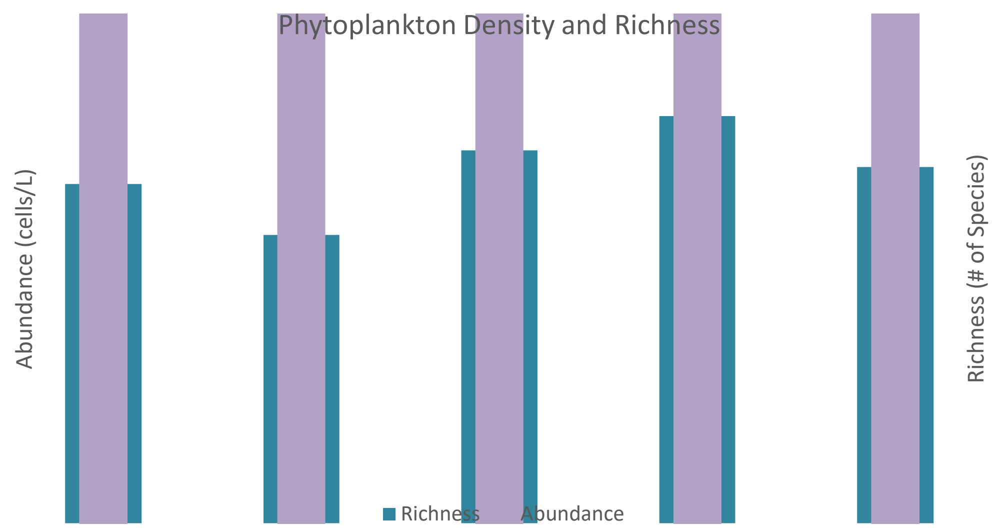


Table 78 - Total and mean phytoplankton abundance and richness recorded in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

Diversity measurements based on the Shannon-Weiner Index reveal the relatively highest value of 1.74 attributed to sampling station PLK2, though having the relatively lowest cell count and lowest number of representative genera as recorded. Inversely, the lowest diversity value at 1.08 was determined to be at sampling station PLK1, though having the highest cell density a high species richness in this survey. In normal conditions for aquatic biota and the associated habitat, the resulting diversity index is more than a 2.0 value. Computed values above 3.0 indicate that the habitat structure is stable and balanced, while values midway from 1.0 to 2.0 describe a threatened condition. Furthermore, values lower than 1.0 indicates pollution and degradation of habitat structure (Goncalves and Menezes, 2011); however, it should be noted that the diversity index very rarely exceeds a 4.5 value.

In terms of evenness, the computed index among the four sampling stations was relatively low ranging from 0.36 in sampling station PLK1 to 0.62 in sampling station PLK2. This indicates that the phytoplankton community along the sampling stations is not evenly distributed with some genera dominating as relative to others, which is in this case, *Chaetoceros* spp. However, it should be noted that sampling station PLK2, aside from having the relatively highest evenness value as stated, it also has the highest diversity value despite having the least cell density and least representative genera. This is due to the relatively low cell count for *Chaetoceros* spp. in this sampling station as compared to its densities in the other sampling stations, which then allowed the densities and representations of other genera and species to compensate presence in their habitat and niches.

Phytoplankton abundance is highly variable and seasonal, but the diversity measurements in the four sampling stations is indicative of stressful conditions caused by a disturbance which may possibly result from factors like high turbidity and eutrophication within the waters along the vicinities of the project site, which is inversely favorable to the proliferation of tolerant phytoplankton organisms.

The overall impression from the results obtained in the phytoplankton sampling along the survey area is fair, but should be taken into account - as reflected by the relatively low diversity values, which is contrasted by dominant populations of certain organisms, as well as the inclusion of potentially harmful genera to the human populace, i.e., *Pseudonitzschia* spp., and *Dinophysis* spp. as recorded during the sampling period. The presence of these indicator organisms should be considered in a system of periodic monitoring that should be mandatory implemented in all phases of the project.

A. Zooplankton Diversity

A total of 378,430 ind/m^3 distributed among 13 zooplankton groups (in adult and larval forms) were identified and recorded from four sampling stations (PLK1-PLK4) in pre-set locations by GIS along the marine waters offshore from the coastline of Candelaria Town to assess and compare the microscopic biota located within as a primary impact area of the WESTCHINAMIN Mining Project in Candelaria – Zambales on 06 June 2018. Table 22 and Figure 40 features the zooplankton groups composed of:

- Copepods in adult forms; i.e., **calanoid** (10,530 ind/m^3), **cyclopoid** (75,188 ind/m^3), and harpactoid (17,353 ind/m^3) with a collective total of 103,071 ind/m^3 at 27.2% composition;
- Other adult forms such as: **flatworms** (4,473 ind/m^3) at 1.2% composition, **larvacean tunicates** (5,945 ind/m^3) at 1.6% composition, *Tintinnopsis* protozoans (18,146 ind/m^3) at 4.8% composition, and **radiolarians** = marine protozoans (425 ind/m^3) at 0.1% composition;
- The larval forms of **nauplius and copepodite**, which is the most abundant group having 213,956 ind/m^3 at 56.5% composition;

- Other larval forms such as: **bivalve veligers** (3,680 ind/m^3) at 1.0% composition, **decapod zoae** = crustacean larvae (8,238 ind/m^3) at 2.2% composition, **echinoderm larvae** (2,123 ind/m^3) at 0.6% composition, **gastropod veligers** (15,004 ind/m^3) at 4.0% composition, and **unknown eggs** (3,369 ind/m^3) at 0.9% composition.

Overall, recorded zooplankton consisted ~35% (132,060 ind/m^3) of adult forms, and ~65% (246,370 ind/m^3) of larval forms from the overall total zooplankton count.

The adult zooplankton forms are comprised of 7 groups while the larval zooplankton forms comprise 6 groups as recorded during this survey. A large portion of the adult forms was represented by cyclopoid copepods with 75,188 ind/m^3 at 19.87% composition, while the larval forms was dominated by nauplius and copepodites with a total of 213,956 ind/m^3 at 56.5% composition; of which these were also the most abundant group for the whole documented zooplankton population within the survey area as previously stated.

The larval form groups were dominant than the adult forms due to the abundance of nauplius and copepodites, and supplemented by the densities of gastropod and bivalve veligers, decapod zoae, echinoderm larvae, and unknown eggs. Copepods are the dominant members of zooplankton that serve as major food sources for fish and other marine life. Because of their smaller size and relatively faster growth rates, and because they are more evenly distributed throughout more of the world's oceans, copepods almost certainly contribute far more to the secondary productivity of the world's oceans, and to the global ocean carbon sink than krill and perhaps more than all other groups of organisms together. As such, copepods have a significant role in grazing pressure on the phytoplankton community due to their very high density (Merrel and Stoeker, 1998). The presence of gastropod and bivalve veligers attribute to the findings of the macrobenthos sampling where thousands of ind/m3 of these mollusks have been identified. Ecologically, these dominant groups serve as important links in marine food webs, serving as major grazers of phytoplankton, as components of the microbial loop, and as prey for ichthyoplankton and other larger pelagic carnivores (Turner, 2004).

There were no rare or endemic zooplankton species in the area, and majority of the zooplankton groups are generally common and cosmopolitan in distribution. Likewise, no fish larvae has been recorded during the sampling period; however, the gastropod and bivalve veligers have records of edible genera based on the results of the macrobenthos sampling.

Photomicrographs of zooplankton groups recorded in the survey area are shown in *Plate 35*

Table 79 - Zooplankton composition and abundance (ind/m3) in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

TAXA	SAMPLING STATIONS				Grand	Rel
	PLK1	PLK2	PLK3	PLK4	Total	Abund
Adult forms (7)	**33,972**	**22,420**	**59,165**	**16,503**	**132,060**	**34.90**
Calanoid	1,274	1,783	4,048	3,425	10,530	2.78
Cyclopoid	22,930	11,465	39,236	1,557	75,188	19.87
Harpacticoid	5,945	3,312	1,557	6,539	17,353	4.59
Flatworm	425		4,048		4,473	1.18
Larvacean	1,699	510	3,425	311	5,945	1.57
Protozoan (*Tintinnopsis*)	1,274	5,350	6,851	4,671	18,146	4.80
Radiolarian	425				425	0.11
Larval forms (6)	**53,078**	**38,216**	**79,095**	**75,981**	**246,370**	**65.10**
Bivalve veliger	2,123			1,557	3,680	0.97
Decapod zoae	2,123	3,312	1,557	1,246	8,238	2.18
Echinoderm larvae	2,123				2,123	0.56
Gastropod veliger	8,917	2,038		4,048	15,004	3.96
Nauplius and Copepodite	36,943	31,592	76,292	69,130	213,956	56.54
Unknown egg	849	1,274	1,246		3,369	0.89
Total Abundance (N)	**87,050**	**60,636**	**138,260**	**92,484**	**378,430**	**100**
Mean Abundance = 94,608						
No. of Rep Groups = 13						
Richness	**13**	**9**	**9**	**9**		
Mean Richness = 10						
Diversity (H')	**1.70**	**1.53**	**1.28**	**1.03**		
Evenness (I')	**0.66**	**0.69**	**0.58**	**0.47**		

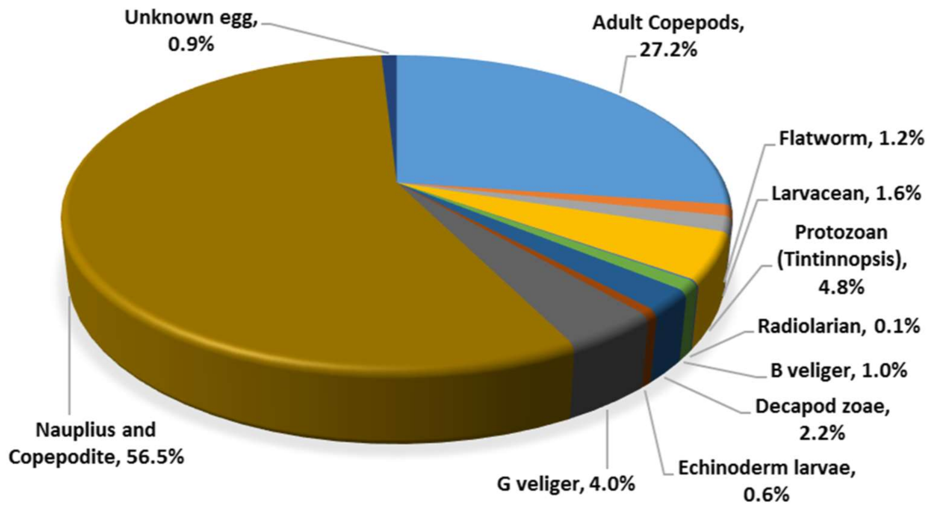
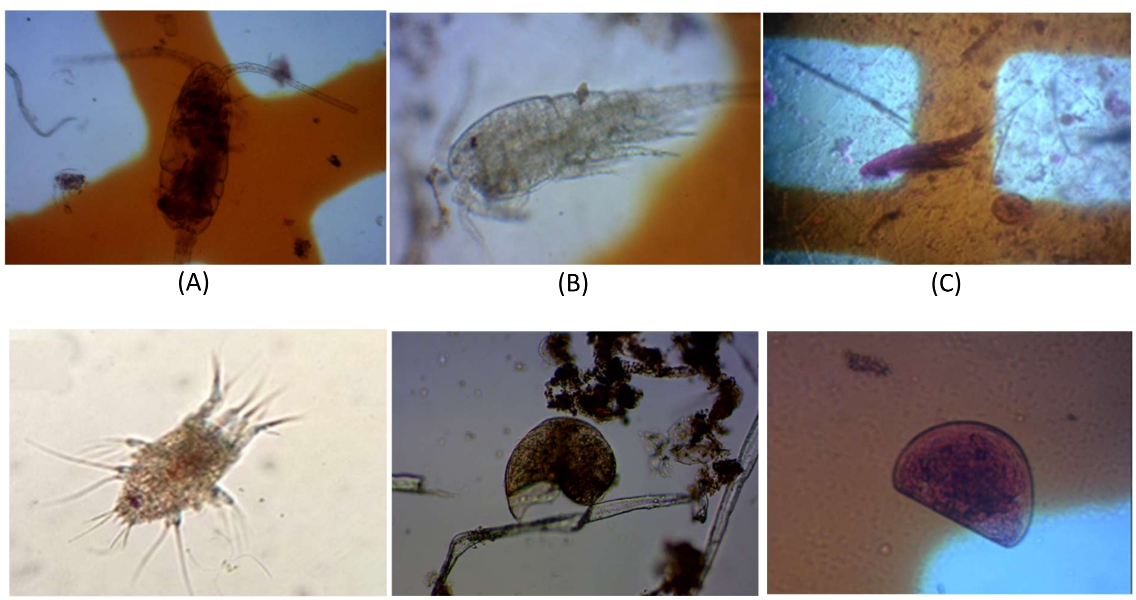


Figure 116 - Percentage composition of major zooplankton groups in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.



(A) (B) (C)

(D) (E) (F)

Plate 35A-12F. Photomicrographs of zooplankton identified and recorded in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018. Top: (A) Calanoid copepod (B) Cyclopoid copepod (C)Harpacticoid copepod; Bottom: (D) Nauplius copepod (E) Gastropod veliger (F) Bivalve veliger

The mean estimate of abundance for the zooplankton community was 94,608 ind/m3 recorded for all four sampling stations during this survey. In terms of spatial distribution, the most number of population counts is attributed to sampling station PLK3 with a density of 138,260 ind/m3, as dominated by nauplius and copepodites (39,326 ind/m3). In terms of species richness, sampling station PLK1 had the relatively highest record of the complete 13 representative zooplankton groups as compared to the other three sampling stations.

In contrast, the lowest zooplankton abundance at 60,636 ind/m3 is attributed to sampling station PLK2, which is located offshore across from the outlet of the Malabon River; while the lesser representation in terms of species richness with nine groups are each attributed to the rest of the sampling stations (PLK2, PLK3, and PLK4). In correlation to the results of the phytoplankton sampling, PLK2 also has the least cell density and least representative genera. This may be due to the displacement of the plankton communities caused by massive expulsion of water and sediments from the river, especially during torrential rains where differential water movement is rapid.

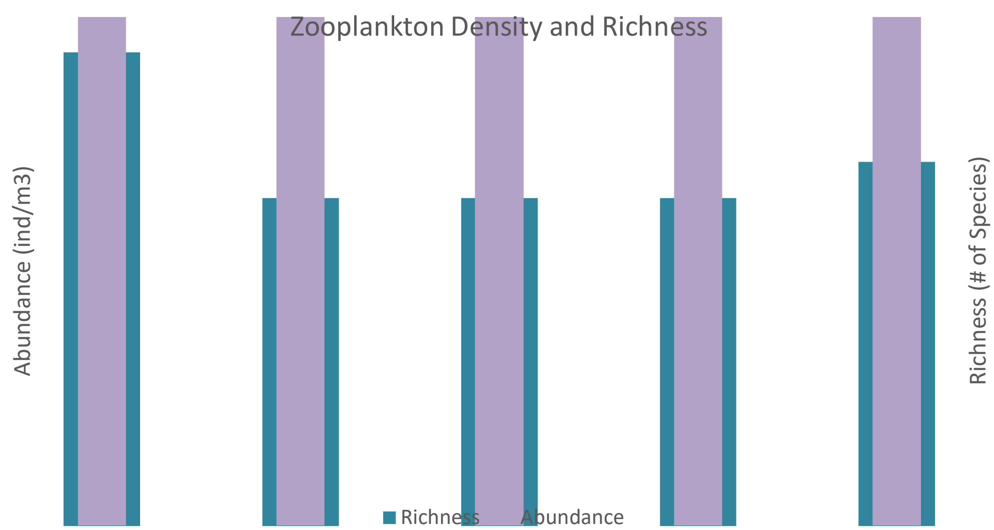


Figure 117 - Total and mean phytoplankton abundance and richness in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

The diversity iversity measurements based on the Shannon-Weiner Index were low (<2.0) in all sampling stations. The relatively highest value of 1.70 is attributed to sampling station PLK1, while the relatively lowest at 1.03 was determined to be at sampling station PLK4. As previously discussed in the phytoplankton section, diversity index values that are greater than 2.0 indicate normal conditions for aquatic biota and the associated habitat. Values above 3.0 indicate that the habitat structure is stable and balanced, while values midway from 1.0 to 2.0 describe a threatened condition; furthermore, values lower than 1.0 indicates pollution and degradation occurring in the habitat structure (Goncalves and Menezes, 2011); the Diversity Index however, very rarely exceeds a 4.5 value.

In terms of evenness, the computed indices for the four sampling stations was not so variable and low ranging with the lowest at 0.47 in sampling station PLK4 to the highest at 0.69 in sampling station PLK2 – which indicates an uneven distribution of the zooplankton community, due to the dominance of a particular group, which in this case are the nauplius and copepodites present with high individual counts in all sampling stations.

It should also be noted that sampling station PLK1 aside from having the highest representative groups, also has the highest computed diversity and close to high evenness values. This is attributed to the presence of all the other groups with corresponding densities within this sampling station, which then again allows the densities and representations of species to compensate their presence in their habitat and niches. The Shannon index decreases as both the richness and the evenness of the community decrease.

The computed diversity and evenness indices indicate that the zooplankton communities in the area are low based on the Wilhm criteria (1975), classifying the diversity index <3.0 as low community stability. As an overall impression, the zooplankton community in the survey area is relatively poor as indicated by a low number of taxa and abundance during the time of survey

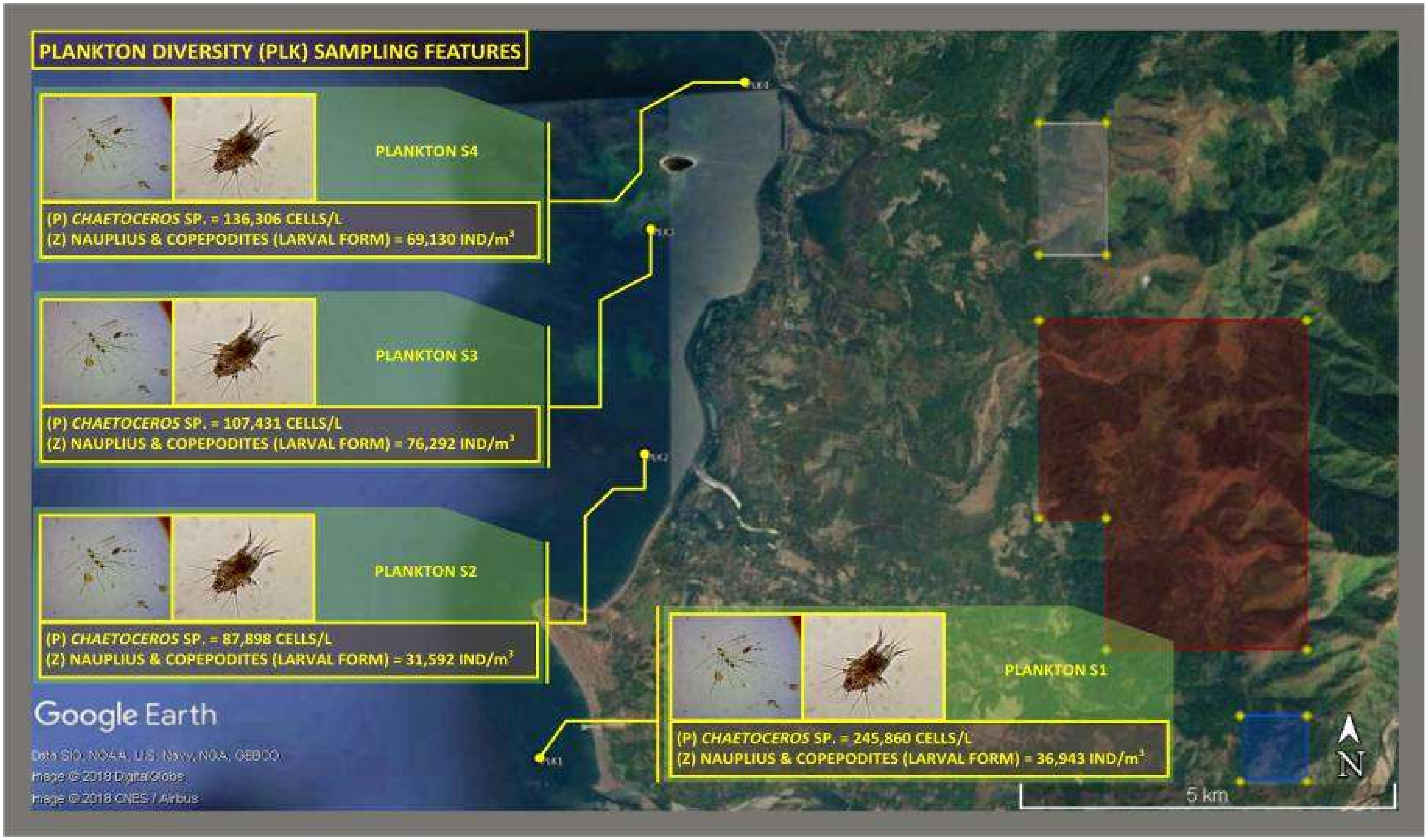


Figure 118 - Highlights of plankton community sampling in four stations during marine ecology baseline assessment for the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; June 2018 (map prepared by Jose Rene Villegas).

2.2.4.5.10 Macro benthos

2.2.4.5.10.1 Macrobenthos Diversity

The macrobenthic community diversity, abundance, and relative composition were determined at four sampling stations (PLK1-PLK4) in pre-set locations by GIS along the marine waters offshore from the coastline of Candelaria Town to assess and compare the microscopic biota located within as a primary impact area of the WESTCHINAMIN Mining Project in Candelaria – Zambales on 06 June 2018.

A total of 8,365 individuals belonging to 16 phyletic groups were quantified for all four sampling stations. These identified taxonomic groups likewise belong to four major phyla; namely Annelida, Arthropoda, Foraminifera, and Mollusca. Among these, the highest number of individuals is attributed to Foraminifera with a total of 5,384 individuals (~64% composition); followed by Mollusca with 2,124 individuals (~26% composition), Annelida with 677 individuals (~8% composition), and the relatively least record of 180 individuals for Arthropoda, comprising ~2% of the total sampled composition (*Figure 119*).

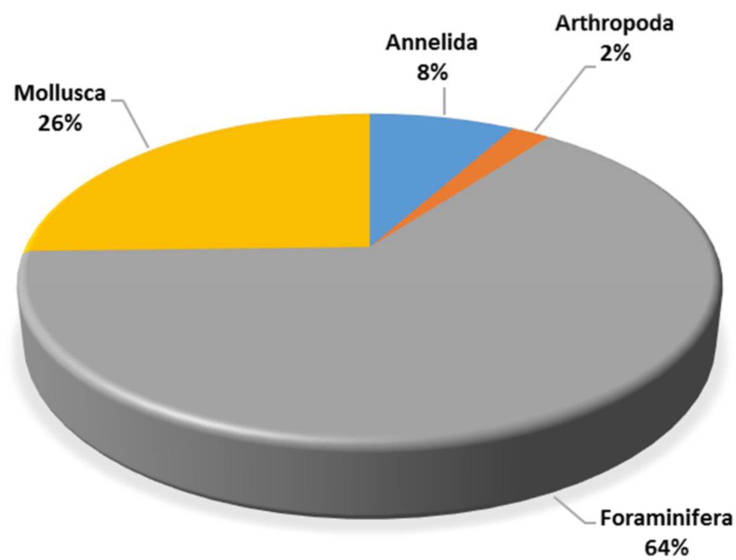


Figure 119 - Percent composition of major macrobenthic groups in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

Foraminifera, though having the most abundant records, had only two representations with 2 family taxa out of the 16 categorized family phyletic groups. This major phyla was largely represented by *Calcarina* sp. from the Family Calcarinidae which constituted 4,208 individuals, making it the most abundant organism comprising ~50% of the total abundance count. Another foraminiferan family (F Peneroplidae) was the next abundant at 1,176 individuals which constitutes ~14% of the total recorded benthic composition. Benthic foraminifera are common in marine sediments; they are cosmopolitan, have a good fossil preservation, and represent a useful tool for oceanographic and paleo-oceanographic studies (MURGESE AND DECKKER, 2005). A wide range of physical, chemical and biological parameters, such as temperature, salinity, depth, sediment, oxygen, food, toxic substances, as well as biological interactions, influence the distribution of benthic foraminifera (MURRAY, 1991; JORISSEN, 1999). Some are abundant only in the deep ocean, others are found only in brackish estuaries or salt marshes along the shore, and most live at certain depths and water temperatures in between.

Mollusca though being the next abundant group with 2,124 individuals (~26% of total composition) had the most representation with 9 family taxa out of the 16 categorized phyletic groups. This major phyla constitutes of bivalves, which were relatively the most abundant with a collective record of 950 individuals comprising ~11%; followed closely by gastropods with 903 individuals also comprising ~11% out of the total sampled benthic organisms. Most of the organisms obtained were juvenile forms of bivalves and gastropods, which indicate a favorable continuity and recruitment of the benthic population. Also among the whole sampled mollusk population, venus clams of the Family Veneridae were the most abundant at 588 individuals, accounting for 7.03% of the total sampling count. These are economically-significant bivalves since these are harvested for consumption or sold by coastal residents as subsistence food. Next abundant are the true cockles of the Family Cardiidae as represented by *Trachycardium* sp. at 317 individuals which constitutes ~3.8% of the total abundance. Generally, these bivalves thrive within and just below the tidal zones, where the most ample quantities of food source may be found; and thus their dominance indicates a favourable niche for their proliferation. It is noteworthy that some of the recorded molluscs are also suitable for human utilization, since these are harvested for personal consumption or sold as subsistence food.

A significant portion of the soft-bottom benthic community surveyed was also represented by annelids which constituted for almost 8% composition with 677 individuals, where three polychaete family taxa have been recorded. Representative organisms from Family Spionidae contributed to the total count with 407 individuals (4.87% composition). Polychaetes are segmented worms which have a pair of fleshy protrusions that bear many bristles, hence this group is sometimes collectively referred to as bristle worms. Polychaetes as a class are robust and widespread, with species that live in the coldest ocean temperatures of the abyssal plain, to forms which tolerate the extremely high temperatures near hydrothermal vents. Polychaetes play an important role in turning over bottom sediments in the sea, while some species are used by humans as bait for fishing. In general, organisms from these phyla serves an ecological importance in marine food chains, ingesting small organisms collected by deposits, or by filter-feeding; which are then consequently being consumed by fishes and other predators.

For the arthropods, the amphipod group (F Gammaridae – scuds) and isopod group (F Gnathiidae – marine isopods) accounts for 1.08% each of the total abundance, recorded to occur only in specific sampling stations; i.e., sampling station BNT1 for F Gammaridae and sampling station BNT4 for F Gnathiidae, during the time of sampling. In populations found in benthic ecosystems, amphipods functions in controlling brown algae growth. The mesograzer behavior of amphipods greatly contributes to the suppression of brown algal dominance in the absence of amphipod predators. Amphipods display a strong preference for brown algae in benthic ecosystems, but due to removal of mesograzers by predators such as fish, the brown algae is able to dominate these communities over green and red algae species. Amphipods are also very sensitive to adverse environmental changes than some species of benthic groups such as polychaetes and mollusks.

Data on the composition, abundance and diversity of the macrobenthos community recorded in the four sampling stations as previously discussed are summarized in Table 23. Images of selected macrobenthos encountered in this survey are shown in *Plate 36*.

Table 80 - Macrobenthos composition, abundance and diversity (# of indiv) in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

TAXA	SAMPLING STATIONS				Grand	Rel
	BNT1	BNT2	BNT3	BNT4	Total	Abund
Phylum Annelida (3)		**361**	**135**	**181**	**677**	**8.09**
F. Capetillidae (bristle worms)		90	45		135	1.61
F. Nereidae (rag worms)		45	90		135	1.61
F. Spionidae (palm worms)		226		181	407	4.87
Phylum Arthropoda (2)	**90**			**90**	**180**	**2.15**
F. Gammaridae (scuds)	90				90	1.08
F. Gnathiidae (marine isopods)				90	90	1.08
Phylum Foraminifera (2)	**271**	**634**	**1,402**	**3,077**	**5,384**	**64.36**
F. Calcarinidae (rotaliacean foraminifera) *Calcarina* sp.	181	317	1,176	2,534	4,208	50.30

F. Peneroplidae (benthic foraminifera)	90	317	226	543	1,176	14.06
Phylum Mollusca (9)	**588**	**271**	**361**	**904**	**2,124**	**25.39**
Class Bivalvia (3)						
F. Cardiidae (true cockles) *Trachycardium* sp.	181			136	317	3.79
F. Veneridae (venus clams) *Gafrarium* sp.	362	226			588	7.03
F. Psammobiidae (sunset clams) *Gari* sp.	45				45	0.54
Class Gastropoda (5)						
F. Cerithiidae (ceriths)		45			45	0.54
F. Conidae (cone snails) *Conus* sp.			90	181	271	3.24
F. Cypraeidae (cowries)			90	181	271	3.24
F. Olividae (olive shells)				271	271	3.24
F. Littorinidae (periwinkles)				45	45	0.54
Class Scaphopoda (1)						
F. Dentaliidae (tusk shells)			181	90	271	3.24
Total Abundance (N)	**949**	**1,266**	**1,898**	**4,252**	**8,365**	**100**
Mean Abundance = 2,091						
Total No. of Representative Organisms = 16						
Richness (S)	**6**	**7**	**7**	**10**		
Mean Richness = 8						
Diversity (H')	**1.59**	**1.73**	**1.30**	**1.47**		
Evenness (I')	**0.89**	**0.89**	**0.67**	**0.64**		

(A) (B) (C)

Plate 36 - Images of recorded macrobenthos in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018. Top: (A) Foraminifera [F Calcarinidae – Rotaliacean Foraminifera, Calcarina sp.], (B) Mollusca [F Cardiidae – True Cockles, juvenile Trachycardium sp.], (C) Mollusca [F Dentaliidae – Tusk Shells, unidentified juvenile].

The abundance and species richness of macrobenthos as recorded in the four sampling stations in this survey are shown in Figure 44, wherein the mean abundance was 2,091 individuals. Spatially, sampling station BNT4 yielded the highest count of macrobenthos with 4,252 individuals, as well as having the most number of representation with 10 phyletic groups. In contrast, sampling station BNT1 had the relatively lowest abundance and representation with 949 individuals and six phyletic groups. All sampling stations are dominated by foraminiferans. Taxa richness is the total number of distinct taxa in a sample. This reflects the health of the macrobenthic community through measurement of the variety of taxa present that generally increases with increasing water quality (PLAFKIN ET AL., 1989). A high percent contribution by a taxon generally indicates community imbalance (BODE, 1988).

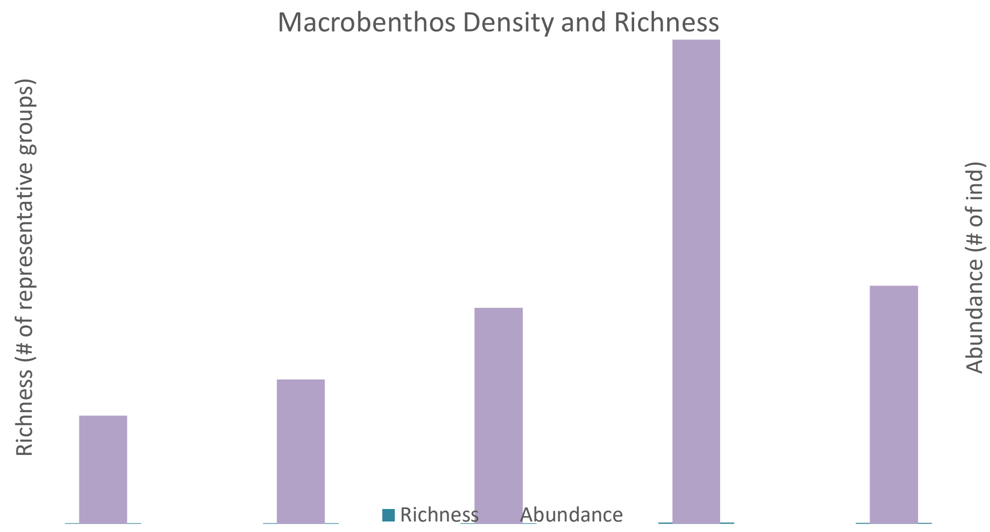


Figure 120 - Total macrobenthos abundance and richness in four sampling stations across the coastline of Candelaria Municipality as MEBA results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018.

Diversity measurements based on the Shannon-Weiner Index are generally low (<2.0); revealing the relatively highest value of 1.73 attributed to sampling station BNT2, while the lowest diversity value at 1.30 was determined at sampling station BNT3. In normal conditions for aquatic biota and the associated habitat, the diversity index value is more than 2.0. Values above 3.0 indicate that the habitat structure is stable and balanced, while values midway from 1.0 to 2.0 describe a threatened condition; furthermore, values lower than 1.0 indicates pollution and degradation of habitat structure (GONCALVES AND MENEZES, 2011); the Diversity Index however, very rarely exceeds a 4.5 value. Diversity is expected to decrease with increasing disturbances (PLAFKIN, ET AL., 1989).

In terms of evenness, the computed Pielou's Index among the four sampling stations was also noteworthy ranging with the lowest at 0.64 in sampling station BNT4 to the highest at 0.89 both in sampling stations BNT1 and BNT2. This indicates that the benthic community in the sampling stations is not quite well distributed due to the dominance of foraminiferans in high individual counts; and may constitute an unstable environmental condition for their existence.

It should be noted that sampling station BNT1, had the lowest diversity but a relatively high evenness value, in which mollusks were the dominant phyletic group in this sampling station. This indicates that only mollusks thrive very well within the areas around the sampling station. Moreover, as previously described sampling station BNT4 had the highest number of abundance and phyletic groups but with a low diversity and evenness value, which indicates an unbalanced localized ecosystem. Sampling station BNT1 is located proximal to the existing port and outlet of the Lauis River south of the survey area, while BNT4 is located proximal to the outlet of the Lucapon River north of the survey area.

However, based on the Wilhm criteria (1975), these diversity values are poor since this criteria classified diversity indices that are <3.0 as low and indicates low community stability. Importantly, there were no rare, endemic, or threatened organisms present, as the identified groups are common and cosmopolitan in distribution.

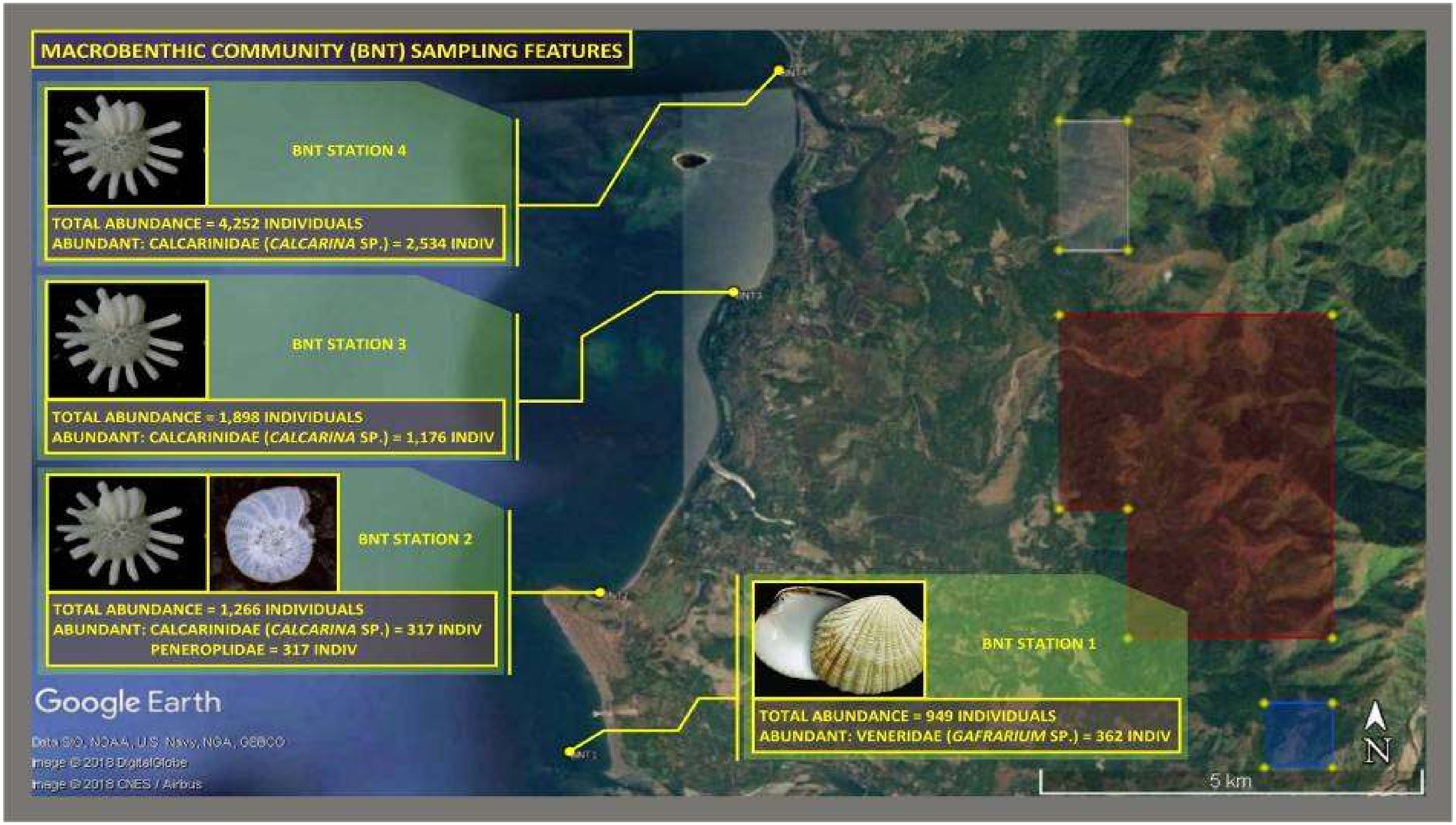


Figure 121 – Summary of macrobenthos abundance and richness in four sampling stations across the coastline of Candelaria Municipality as Marine Ecology Baseline Assessment results for the WESTCHINAMIN MP, Candelaria, Zambales; 06 June 2018

2.2.4.5.10.2 Macro-invertebrates of commercial significance

In the coral and seagrass stations surveyed, the presence of macro-invertebrate organisms was not encountered in significant distribution. A thriving community of marsh clams and venus shells were, however, encountered in the mangrove stations. A total of sixteen (16) species were catalogued, dominated by various bivalves (5 species) and gastropods (7 species. There were three species of echinoderms that included the lucrative sea cucumber and the ball sea urchins. Based on FAO's *Species Identification Guide for Fishery Purposes* (1998), eleven (11) species were noted to have a commercial importance and/or considered edible. Also, most of the species found were of significant interest to fisheries, forming a major part of the marine food chain and serving as diet to many species of fish and crustaceans in the reef ecosystem. Overall, this survey indicates a low biodiversity and population of the macro-invertebrates found in two major ecosystems i.e., coral reefs and mangrove area.

Table 81 - Species of commerically important macro-invertebrates and other macro-invertebrates encountered in three sampling stations in Candelaria, Zambales during marinee ecology baseline assessment in June 2018.

Species Name	Common Name	Habitat	Group
Stichopus chloronotus	Sea cucumber	Sandy area	Echinoderm
Litoria sp	Perwinkle	sand	Gastropod
Cypraea sp	Cowrie	corals	Gastropod
Linkia sp	Sea star	coral reef	Echinoderm
Diadema sp	Sea urchin	corals	Echinoderm
Lambis truncate	Giant spider shell	sand-seagrass	Gastropod
Neritina turrita	Turreted nerith	Sandy-muddy	Gastropod
Trochus niloticus	Top shell	Coral reef	Gastropod
Conus sp 1	Conus shell	Coral reef	Gastropod
Pateloida striata	Striate limpet	Rocks	Gastropod
Tripnuestes gratilla	Sea urchin	Sand-algae	Echinoderm
Tapes sp	Venus shell	Mangrove area	Bivalve
Liconcha sp	Venus shell	Mangrove area	Bivalve
Paphia sp	Venus shell	Mangrove area	Bivalve
Trachicardium sp	Cockle	Sandy substrate	Bivalve

Species Name	Common Name	Habitat	Group
Polymesoda sp	Marsh clam	Mangrove area	Bivalve
Terebralia sulcata	Swamp cerith	Mangrove	Gastropod

Plate 37 - Some commercially important macro-invertebrates catalogued during marine ecology baseline assessment in Candelaria, Zambales – Top Row: marsh clams (Polymesoda sp); sea cucumber (Stichopus chloronotus), another marsh clam (Polymesoda erosa). Bottom: Sea urchin (tripnuestes gratilla, venus clams (Tapes sp and Liconcha sp) and top shell (Trochus sp.) with tiger cowrie (Cyprea sp)

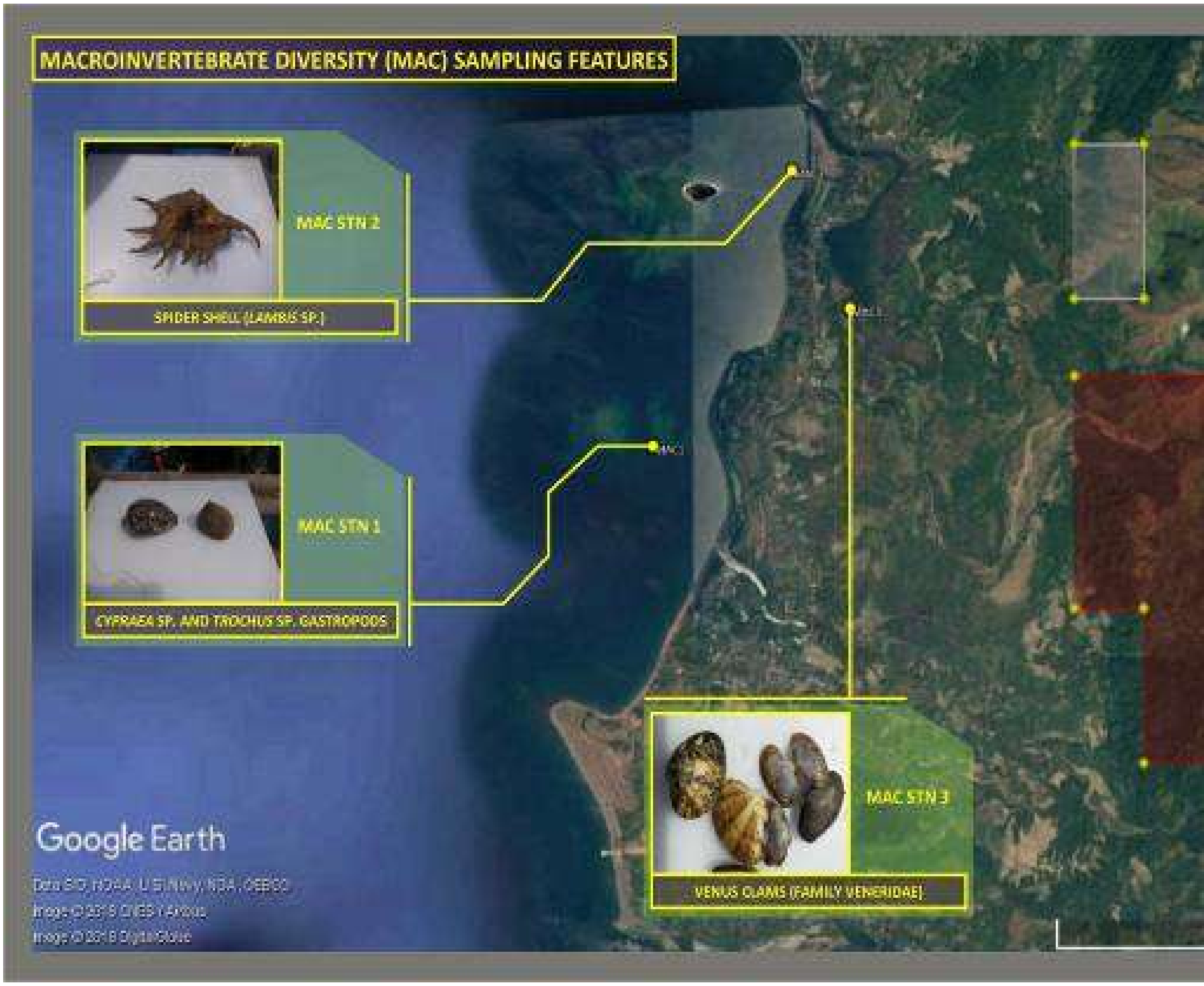


Figure 122 - Macro-invertebrates of commercial importance catalogued in three sampling stations during during mari
the coastal impact area of the proposed ChinaMin Nickel Mining Project in Candelaria, Zambales; 06 June 2018; (map

2.2.4.6 Presence of pollution indicator species

There are no marine species of significant use as pollution indicators in the coastal impact of the project site surveyed.

Corals – The growth or demise of corals have been associated to suffocation from sediment intrusion into the coral polyps as corals thrive well in clear waters with unimpeded sunlight penetration in the water column. Coral suffocation is therefore associated to increasing suspended solids and silt in the water column, normally attributed to land-based issues such as land conversion and loss of vegetation. Based on observations of dead coral with algae values across all three coral reef assessment stations undertaken in the survey, silt pollution in the project site and contiguous coastal environs is occurring but these have not reached extreme proportions to cause widespread coral polyp mortality or suffocation. The correlation of sediment intrusion and coral suffocation can therefore be a valuable analogy for determining impacts of project-induced silt and sediment pollution in coastal waters.

Bivalves – Bivalves have been used to determine biotoxin levels that can be harmful to humans if they are consumed in hyper-nutrient episodes in coastal waters, especially species belonging to the mussel and oyster taxa. The bivalve communities in the project site are few and their abundance is unimpressive. There are no mussels in the area and oyster occurs only in isolated individuals amongst rock boulders near mangrove swamps. Amongst the bivalves encountered in the survey, the marsh clams (*Polymesoda sp*) would be the most susceptible to marine pollution but its habitat - burrowed in muddy substrate would make it an unlikely candidate for biotoxin ingestion. Nevertheless, contaminated mine tailings from the mine site, carried down by rivers to Uacon Lake can seriously affect population of the marsh clams.

Fish - 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 (such as Anchovies). No species of fish capable of filtering harmful plankton-contaminated water were encountered in the survey.

Plankton – Excessive nutrient loading, even if the coastal area is far from the mining project, exacerbated by domestic wastewaters, can lead to plankton blooms and eutrophication. The potentially harmful phytoplankton species observed was *Dinophysis caudate*. This species is capable of producing toxins associated with Diarhetic Shellfish Poisoning (FAO, 2000). However, the current numbers of the dinoflagellate is very low and was recorded only in three stations. Since there is no extensive shellfish farming in the area, the possibility of shellfish biotoxin ingestion can be ruled out but continued monitoring is highly recommended. Currently, the densities of plankton groups observed in the coastal area within the vicinity of the project site do not indicate proportions that can cause the occurrence of Harmful Algal Blooms (HAB).

2.2.4.7 Predicted Environmental Impacts; threats to abundance and diversity of coastal resources

The same potential threats to coastal resources and habitats can emanate both from establishment and operational stages of the proposed nickel mining project.

2.2.4.7.1 Coral reefs and associated demersal fisheries

Remaining corals in the primary and secondary impact area of the proposed mining project are few and dispersed and the coral colonies inside the marine protected areas are the last coral ecological niche in the municipal waters. Thus the corals in the two MPAs need to be protected and recruitment needs to be enhanced. Any anthropogenic issue emanating from the Project will have cumulative incremental impacts on the remaining coral species inside the MPA. Accelerated and excessive erosion will lead to coral polyp suffocation if silt and sediment streams reach coastal waters as a result of poor containment measures. 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 fish sanctuaries. If erosion from point sources will not be controlled effectively, the effect will be progressive siltation, starting in the rivers and consequently impairment of coastal water integrity and invasion of reef and seagrass habitats. The 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 morphology, decreased reproductive output, shortened larval duration and subsequently, low larval recruitment and survival.

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 the land-sea interface, in many instances, domestic wastewater from households, open latrines, fertilized croplands, watersheds and denuded mountain slopes. It is likely too that organic matter from the mining project's operation and facilities, including sediments during construction, can be a source of nutrient loading in nearshore waters.

Illegal fishing practices, such as the use of explosive devices and poisons derived from natural sources to capture live fish (e.g., tubli) remain as potential threats to the continued restoration of coral reef colonies and its associated fish population. Also, the issue of overfishing will be difficult to address unless alternative and supplementary sources of income for coastal communities can be enabled. Intensifying eco-tourism, with inclusive benefits, can be a major vehicle to achieve improvements in rural income over time.

2.2.4.7.2 Marine Pollution and Quality of seawater

In spite of the incessant sediment intrusion at the present time, the quality of the seawater in the project's coastal impact area remains viable for coral and fish population replenishment and the migration of fish towards the reef flats. Accidental spillage of oil and grease from project facilities, as well as spillage from nickel processing and loading, if carried downstream through rivers and rainwater, can cause seawater pollution that can end up on the substrates within the coast, river and estuary, in the process damaging macro-benthic invertebrate population in the area. In certain times, such oil slicks can be forced to the bottom by tidal action and thereafter pollute coral colonies within its pathway. While this issue is not anticipated to be severe, oil slicks caused by unintentional spills in the project site, even as it is far from the coast, may remain sequestered in waterways and drainage facilities or carried by rainwater run-off to coastal waters and are dispersed in small blotches towards the direction of tidal movement. The risk of shellfish contamination from such waste oils can be far reaching, as oil can invade macro-invertebrate habitats that may cause immediate demise.

2.2.4.7.3 Fisheries

The local fisheries sector is currently beset with declining yields and looming long term unprofitability and loss of incomes from small-scale fishing. While there is no direct anthropogenic issue that can be caused by project establishment and operation on stocks of fish, further damage to coastal habitats such as coral reefs, seagrass beds and mangroves caused by pollution and excessive sediment intrusion will further deteriorate fisheries productivity as recruits and spawners alike will evade the unfavorable condition of coastal waters in Candelaria.

2.2.4.7.4 Seagrass Beds

Sediment streams from project construction will likely amplify coastal water turbidity, in the form of total suspended solids (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 expansion of seagrass settlement in the shallow portions of the sea in front of Bgy.Uacon can be discouraged and be prevented if sediment intrusion becomes extreme and the benthic substrate is blanketed by loose silt.

2.2.4.7.5 On Mangrove resources

It is unlikely that the power plant project will have direct impacts on mangrove trees. Sediment fluxes are unlikely to depress mangrove growth and recruitment. In fact, increasing the mangrove cover through reforestation will improve its natural function as sediment traps and pollution sink.

2.2.4.7.6 On macro-invertebrates

Alteration of macro-invertebrate habitats – particularly breeding grounds of the marsh clam may affect growth and recruitment. Breeding areas of the bivalve needs to be identified, delineated and protected from degradation. The Project shall take all precautionary measures to prevent silt and sediment intrusion into the areas were shellfish are being harvested. Any impacts will be minimal and of short duration. Even in Uacon lake, the benthic communities are expected to retain its population if excessive sedimentation is effectively controlled original. Recovery rates of soft bottom benthic communities are partly a function of habitat type and water depth. Benthic adaptation and recolonization should be quite rapid and could occur within a short time in the face of disturbance.

2.2.4.7.7 On phytoplankton communities

The immediate impact of sediment loading in coastal waters emanating from the open mines would be increased coastal water turbidity and lowered photosynthesis for communities of plankton. Loss of some plankton groups may be possible but the mortality of plankton community in the impact area can be readily replenished through water currents and tidal influences from other areas unaffected by the silt streams and by the fact that being passively drifting organisms, plankton can easily repopulate even in local areas. Planktons are resilient and will readily re-colonize seawater even in turbid conditions. Increased nutrient loading through sediment transport can be a more likely pathway for occurrence of HABs in the coastal area if the suspended organic matter (OM) causes hyper-nutrient levels and euthrophication. 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 a fact however, that episodes of algal blooms can be triggered by hyper-nutrient loading and untreated domestic wastewaters from various point sources.

2.2.4.7.8 Possible Threats to the Benthic Community

The variability of macrobenthic organisms are generally affected by abiotic factors such as substrate types, salinity, water temperature, and dissolved oxygen. Biotic factors like recruitment, predation, and natural mortality could also affect the changes in macrobenthic community. Other disturbance on the habitat in either anthropogenic or natural in origin, like water pollution and displacement of bottom sediments that may cause severe depletion on their population. Macrobenthic organisms, because of their contact with sediments reflects that their relative abundance, ubiquity, and sedentary nature, are considered to be suitable bio-indicators of the long-term environmental status of sediments contaminated by hydrophobic organic micropollutants. (LOUATI ET AL., 2014).

The overall impression for the macrobenthic diversity assessment in the survey area is poor as indicated by low abundance and low diversity. However, the low diversity and abundance as analyzed is indicative of an introduced localized disturbance which may be natural or anthropogenic from its very cause and source.

Disturbance of the localized ecosystem by high-impact sedimentation through run-offs would cause sediment discharge and alteration of the bottom substrate that would lead to turbidity of the water column and displacement of benthic organisms since their habitat is compromised. It should be implemented and observed that project activities be designed, planned, and conducted in an environmentally suitable process so as not to pose a significant impact on this aquatic community. The macrobenthic community however, are also known to be resilient as some groups would migrate to less stressful areas, while a few tolerable organisms remain in the affected area; or replenishment of the community will occur with either the existing or new species establishing their population and niches through time.

2.2.4.8 Mitigation Measures

2.2.4.8.1 Prevention of siltation and sedimentation

The major issue arising from the project construction and operation phase is the increase in sedimentation of coastal waters caused either directly from (i) loose sediments generated by open pit clearing, grubbing and stripping and seepage of sediment-loaded water during rainfall events and carried downstream through run-offs and river systems, or indirectly though (ii) run-off from non-point sources.

The bottom line in any pollution control program is the mitigation of pollutants at the source. An accounting of areas already subjected to heavy sediment load should be undertaken and such areas should be demarcated immediately and earmarked for siltation reduction measures. Potential pathways of project-sediment plumes, such as the river systems and denuded slopes in the mine's immediate impact area. The main strategy to curtail potential sediment and silt waste streams from spilling over to the coastal waters is to contain erosion at source and entrap fugitive sediments in project waterways and drainage system by installing a series of filters and settling ponds. During construction of the facilities, silt curtains of geo-textile materials will be installed in strategic points to filter sediments and substantially reduce suspended sediment in waters released to rivers and waterways that may end up in the coastal area. In construction sites and earthworks in the main project complex sediment prevention will be reinforced by the construction of entrapment screens in the waterways and drainage canals that divert waste streams into settling ponds. Impacted water from the clearing and grubbing of the open pit mine, as well as those emanating from the construction of facilities will be diverted to the sediment traps. Mined areas will be immediately revegetated in order to reduce erosion.
Periodic monitoring of total suspended solids (TSS) in coastal waters in coastal waters fed by rivers from the project site will be undertaken in tandem with monitoring issues associated with coral cover monitoring.

2.2.4.8.2 Curtailment of domestic wastewater pollution

The use of 3-chambered septic tanks shall be installed in all project facilities where wastewaters and other effluents are generated. Waste minimization will be practiced in all aspects of project operation. The objective is to ensure that pollution-causing effluents that can be potentially carried downstream are treated at the source.

2.2.4.8.3 Prevention of oil and grease spill; coal spillage from jetty

Clean practices in oil and fuel dispersal will be strictly enforced in the project site and fuel dispensing facilities. Fuel and oil-based residues will be collected and disposed of properly. To minimize accidental oil spill effects on marine life there is a need to prepare and implement Oil Spill Contingency Plan with the intent of giving guidelines to the management as to the steps and actions to be taken when oil spill incident has occurred or is likely to occur. This will include cleanup strategies that focus on removing oil and oily debris from the upper swash zone once oil slicks has come ashore if such accidents do occur. Where thick oil slick cannot be naturally removed, low pressure flushing or vacuum may be employed at the outer fringes.

2.2.4.8.4 River rehabilitation through assisted natural regeneration and re-vegetation

River rehabilitation and siltation mitigation projects shall be focused on the restoration of the ecological ability of the two river systems emanating from the project site and associated estuarine areas to sequester sediments and organic debris. This will be done with the collaboration of the local government and FARMC. The placement of sediment entrapment structures will be reinforced by re-vegetation of river banks (for example, through Vetiver and bamboo planting) and mangrove replanting in the river estuary. Riverbank vegetation, especially the deep-rooted Vetiver and sturdy bamboo, helps to stabilize river banks and prevent further scouring that contribute to siltation. Other dense vegetative cover along the river systems contribute to sediment trapping, building up soil accretions along corners over the long term. Mangroves act as sediment traps and pollution sink in river mouths and estuaries, trapping many organic debris and sediments washed down from hillsides and from roads and public places. The absence of mangrove forests also affect shoreline protection from strong waves, resulting in some cases, beach or shoreline erosion.

Riverbank vegetation will have economic uses that community members or employees can eventually utilize. There is a market for aromatic oils derived from Vetiver grass while bamboo is popularly used as material for diverse cottage industry-based products.

The mangrove ecosystem has numerous ecological and economic benefits. Mangroves provide nursery grounds for fish, prawns, and crab and supports fisheries production in coastal waters. One significant non-monetary benefit is the nutrients produced from decomposing leaf litter. This partially decomposed detritus is exported to and used by the many aquatic organisms of lagoons and nearshore ecosystems, such as estuaries, seagrass beds, and coral reefs. Commercial species of shellfish, shrimps, and fish rely heavily upon this nutritious food source.

2.2.4.8.5 *Support the effective management of marine protected areas in Candelaria as a strategy to enhance coral recruitment and fish population recovery.*

In coastal resource management, the most proven strategy to rehabilitate both coral reef colonies and associated fish populations over the long term is the establishment of Marine Protected Areas. Supporting the effective management of the two MPAs in Candelaria provides the impetus for greater efforts for restoration of ecosystem functions and structures and promotes a high degree of corporate social responsibility. Conservation zones in the marine environment are areas where fragile and ecologically significant habitats and its associated biodiversity are conserved, consistent with best practices in adaptive protected area management. The establishment of core conservation zones is a widely recognized strategy that is based on the premise that certain components of the natural environment should be conserved in perpetuity for their own sake and not for any utilitarian purpose, even for that matter, mine waste receptors. The following are the objectives of this activity:

- protection and maintenance of marine biological diversity and its associated natural resources;
- enhancement of the potential for fish stock replenishment in the surrounding coastal waters through the allocation of enough habitats for protection of maturing species of fish;
- protection of the remaining coral habitats and associated ecological structures;
- provide a refuge for intensively fished species of fish;
- protection of species of the Giant Clam *Tridacna gigas/Tridacna spp.* which is a unique species under international protection; and
- enhancement of recreational assets in the marine environment.

2.3 Air

2.3.1 Meteorology

2.3.1.1 General Climate

The climate of Zambales province belongs to Type I of the Modified Coronas Classification (*Figure 123*) having two pronounced seasons, dry from November to April and wet during the rest of the year. Maximum rains usually occur from June to September.

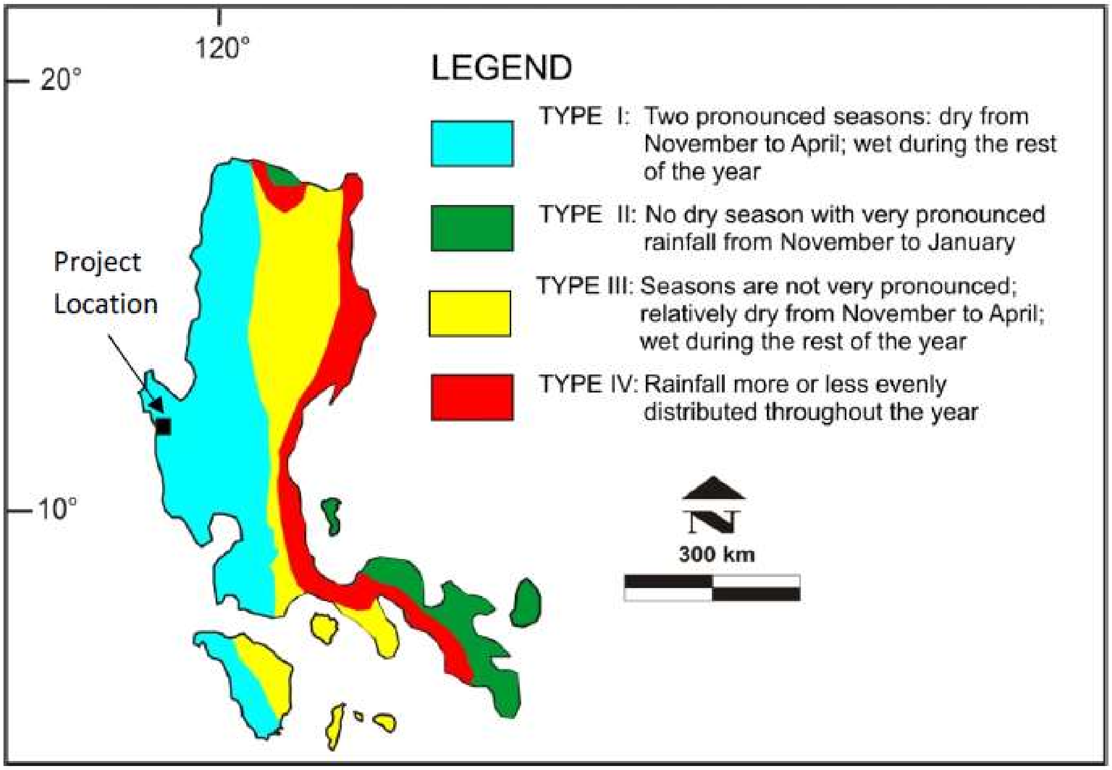


Figure 123 - Climate Map of Luzon

Data on climatological normals and extremes, as well as 5-year monthly temperature and rainfall data, were obtained from the Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA). Climatological data used in this report were from the nearest PAGASA synoptic station located at Iba, Zambales. Climatological normals for the period 1971 to 2000 are presented in *Table 82* while climatological extremes as of 2009 are shown in *Table 83*. Latest 5-year monthly data on rainfall and temperature (2006-2010) were also obtained and are shown in *Table 84* and *Table 85* respectively.

Table 82 - Climatological Normals

Month	Rainfall		Temperature						Vapor Pressure (mbs)	Rel. Hum. %	MSLP (MBS)	Wind		Cloud Amount (okta)	No. Days w/	
	Amount (mm)	No. of RD	Max (°C)	Min (°C)	Mean (°C)	Dry Bulb (°C)	Wet Bulb (°C)	Dew Pt. (°C)				DIR (16 pt)	SPD (mps)		TSTM	LTNG
JAN	3.3	1	30.8	20.4	25.6	25.5	22.1	20.7	24.3	74	1012.4	NW	3	4	0	0
FEB	5.2	1	31.3	20.7	26.0	25.9	22.5	21.1	24.9	75	1012.4	NW	3	3	0	0
MAR	16.0	2	31.9	21.6	26.7	26.8	23.3	22.0	26.2	74	1011.8	E	3	3	1	2
APR	31.6	4	33.1	23.2	28.2	28.5	24.6	23.2	28.2	73	1010.2	E	3	3	5	8
MAY	297.8	12	32.7	23.5	28.1	28.3	25.1	24.0	29.6	77	1008.8	E	3	5	14	19
JUN	489.2	18	31.4	23.3	27.4	27.5	25.0	24.1	29.9	82	1008.0	E	3	6	14	17
JUL	840.0	24	30.4	22.8	26.6	26.7	24.7	24.0	29.7	85	1007.5	E	3	6	15	17
AUG	1019.3	25	29.8	22.7	26.3	26.4	24.6	23.9	29.7	86	1007.5	E	3	7	13	14
SEP	544.7	21	30.5	22.8	26.7	26.6	24.7	24.0	29.8	86	1008.3	E	3	6	14	17
OCT	273.7	14	31.3	23.1	27.2	27.1	24.7	23.8	29.4	82	1008.8	E	3	5	8	15
NOV	74.5	6	31.4	22.5	26.9	26.9	23.9	22.8	27.6	78	1010.2	E	3	4	2	6
DEC	14.9	3	31.1	21.5	26.3	26.1	22.9	21.6	25.7	76	1011.7	E	3	4	0	2
ANNUAL	3610.1	131	31.3	22.3	26.8	26.9	24.0	22.9	27.9	79	1009.8	E	3	5	86	117

Table 83 - Climatological Extremes

	TEMPERATURE (°C)				GREATEST DAILY RAINFALL (MM)		HIGHEST WIND (MPS)			SEA LEVEL PRESSURES (MBS)			
MONTH	HIGH	DATE	LOW	DATE	AMOUNT	DATE	SPD	DIR	DATE	HIGH	DATE	LOW	DATE
JAN	37.2	01-30-1971	13.0	01-18-1992	29.7	01-24-1935	18	NW	01-19-1974	1020.9	01-14-1955	1002.1	01-05-1999
FEB	37.2	02-20-1972	13.0	02-02-1993	47.6	02-23-2001	16	E	02-11-1974	1020.0	02-04-1964	1004.0	02-21-2001
MAR	38.5	03-27-1973	11.0	03-08-1993	87.1	03-17-1949	16	SE	03-27-1994	1019.6	03-03-1968	1001.3	03-06-1999
APR	38.8	04-22-1973	16.0	04-05-1993	72.2	04-18-1998	24	SW	04-20-1978	1018.2	04-08-1965	1001.5	04-21-1956
MAY	38.0	05-11-1993	15.0	05-31-1992	543.4	05-23-1976	41	SW	05-22-1978	1015.3	05-07-1957	989.6	05-17-1989
JUNE	38.2	06-29-1995	13.0	06-04-1995	356.4	06-27-1960	47	SW	06-23-1976	1015.6	06-06-1966	980.9	06-29-1964
JULY	38.6	07-02-1995	14.0	07-21-1992	406.1	07-28-1952	36	W	07-25-1980	1014.5	07-07-1953	992.1	07-04-2001
AUG	35.7	08-27-1969	14.0	08-26-1992	437.7	08-31-1970	29	S	08-25-1978	1014.6	08-22-1953	980.0	08-29-1959
SEP	35.6	09-24-1972	12.3	09-10-1978	623.7	09-21-1935	30	SW	09-16-1977	1015.1	09-01-1971	990.0	09-27-1978
OCT	37.0	10-23-1972	17.8	10-21-1960	325.9	10-13-1960	40	SE	10-27-1978	1017.4	10-30-1961	983.8	10-11-1989
NOV	38.3	11-07-1972	15.0	11-30-1992	291.4	11-14-1977	31	NNW	11-04-1980	1018.4	11-24-1957	981.2	11-04-1967
DEC	38.1	12-20-1971	15.0	12-07-1992	138.5	12-04-1936	18	E	12-25-1980	1019.7	12-10-1967	996.6	12-14-1964
ANNUAL	38.8	04-22-1973	11.0	03-08-1993	623.7	09-21-1935	47	SW	06-23-1976	1020.9	01-14-1955	980.0	08-29-1959
Period of Record	1910-2009				1903-2009		1966-2009			1949-2009			

Table 84 - Monthly Total and Annual Rainfall Data for the Period 2006-2010 (mm)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2006	34.1	5.8	25.5	15.4	56.8	244.3	1593.5	896.2	315.5	511.1	73.7	23.4	3795.3
2007	5.5	0.4	39.6	7.4	125.8	35.8	539.9	1056.6	752.1	296.5	217.8	2.0	3079.4
2008	14.8	23.4	16.3	35.2	309.1	366.5	490.1	651.2	871.2	91.9	174.6	10.0	3054.3
2009	3.0	21.2	20.0	180.0	257.7	1006.5	981.3	323.6	1275.2	263.6	2.4	0.0	4334.5
2010	0.4	0.0	6.4	27.4	107.0	315.6	353.1	787.4	356.3	461.2	112.5	-1.0	2527.3
TOTAL	**57.8**	**50.8**	**107.8**	**265.4**	**856.4**	**1968.7**	**3957.9**	**3715.0**	**3570.3**	**1624.3**	**581.0**	**34.4**	**16790.8**
MEAN	**11.6**	**10.2**	**21.6**	**53.1**	**171.3**	**393.7**	**791.6**	**743.0**	**714.1**	**324.9**	**116.2**	**6.9**	**3358.2**
STDEV	**13.7**	**11.3**	**12.3**	**71.8**	**107.0**	**365.0**	**506.4**	**277.5**	**396.2**	**167.4**	**84.4**	**10.2**	**707.9**

Table 85 - Monthly Mean and Annual Temperature for the Period 2006-2010 (°C)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
2006	26.6	27.0	27.6	29.1	29.0	28.6	26.6	26.7	27.7	27.4	27.0	26.6	27.5
2007	26.8	26.3	27.0	29.1	28.7	29.2	28.4	27.0	27.2	27.6	27.0	26.9	27.6
2008	27.2	27.0	27.7	29.3	27.8	28.4	27.4	26.6	27.0	27.4	28.1	27.4	27.6
2009	26.2	27.5	28.3	28.3	28.3	27.0	26.9	27.9	27.1	27.1	28.1	27.0	27.5
2010	27.0	26.8	28.2	29.6	30.2	28.9	28.7	27.6	28.2	28.1	28.1	27.7	28.3
TOTAL	**133.8**	**134.6**	**138.8**	**145.4**	**144.0**	**142.1**	**138.0**	**135.8**	**137.2**	**137.6**	**138.3**	**135.6**	**138.4**
MEAN	**26.8**	**26.9**	**27.8**	**29.1**	**28.8**	**28.4**	**27.6**	**27.2**	**27.4**	**27.5**	**27.7**	**27.1**	**27.7**
STDEV	**0.4**	**0.4**	**0.5**	**0.5**	**0.9**	**0.8**	**0.9**	**0.6**	**0.5**	**0.4**	**0.6**	**0.4**	**0.3**

2.3.1.2 Rainfall

Rainfall normal values recorded in Iba, Zambales Synoptic Station reflect the characteristics of a Type I climate having two pronounced seasons. Low amounts of rainfall were recorded during the months of November to April ranging from 3.3 mm to 74.5 mm. The months of May to October experience high amounts of rainfall ranging from 273.7 mm to 1,019.3 mm. Lowest monthly rainfall is typically experienced in January. On the other hand, highest monthly rainfall usually occurs in August. On the average, the province receives 3,610.1 mm annual rainfall. The number of rainy days typically ranges from 1 to 6 during the dry season and 12 to 25 on the wet season. The total number of rainy days in a year is normally 131. Recent rainfall data (see *Table 84*) show an annual average of 3,358.2 mm for the period 2006-2010. As of 2009, the greatest daily rainfall recorded in the station was 623.7 mm (dated 21 September 1935).

2.3.1.3 Temperature and Relative Humidity

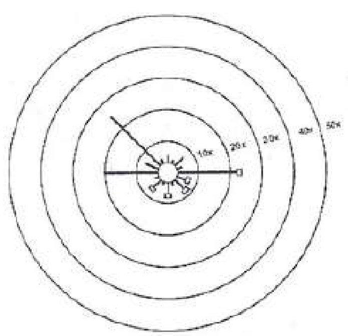
Average temperatures recorded in the area typically vary between 25.6 °C and 28.2 °C with an annual average equal to 26.8 °C. Coldest and hottest days logged were 11.0 °C and 38.8 °C, respectively. Latest temperature data is shown in *Table 85*. Normal values of relative humidity range from 73% to 86% with an annual average of 79%. Dry months are usually less humid than the rainy months. Relative humidity varies between 82% and 86% from June to October while the rest of the year normally experiences relative humidity values ranging from 73% to 78%.

2.3.1.4 Wind Speed and Direction

The prevailing wind direction for most of the year is easterly from March to December. Wind speed, on the other hand, is constantly at 3 mps throughout the year. Movements of air streams in the area are generally influenced by Southwest Monsoon (*Habagat*) which affects the country from May to September. Rainfall during the wet months is usually brought by this phenomenon. *Figure 124* presents the wind rose diagram and frequency table of wind speed and direction for Iba, Zambales Station for the period 1971-2000. Based on the data presented, the area normally experiences wind speeds within the 1 – 4 miles per second range 89.5 percent of the time. The wind rose diagram shows that the area is dominated by easterly, north-westerly and westerly winds having frequency values at 25.7%, 15.2% and 10.3%, respectively. Wind direction would dictate the movement of possible air pollutants from the Project area.

2.3.1.5 Tropical Cyclones/Typhoons

Tropical cyclones are largely the source of high amounts of rainfall in the country. The project area lies on a zone experiencing an average of five cyclones in three years as shown in *Figure 125*. Most of the tropical cyclones that enter the Philippine Area of Responsibility come from the Philippine Sea side. The Zambales region is usually traversed by tropical cyclones during the months of May to September following northwestward direction (see *Figure 126*).



Direction / Speed (mps)	N	NNE	NE	ENE	E	ESE	SE	SSE
Calm								
1-4	3.9	0.7	4.9	2.0	23.4	4.4	6.2	0.5
5-8	0.2	0.0	0.1	0.0	2.3	1.1	1.2	0.3
>8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Total	4.1	0.7	5.0	2.0	25.7	5.5	7.5	0.8

Direction / Speed (mps)	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
Calm									0.1
1-4	5.2	1.4	6.0	1.2	10.0	4.0	14.7	1.0	89.5
5-8	1.9	0.5	0.9	0.2	0.2	0.1	0.4	0.1	9.5
>8	0.2	0.1	0.2	0.0	0.1	0.0	0.1	0.1	0.9
Total	7.3	2.0	7.1	1.4	10.3	4.1	15.2	1.2	100.0

Figure 124 - Wind Rose Diagram and Frequency Table for Iba, Zambales from 1971-2000 (Annual)

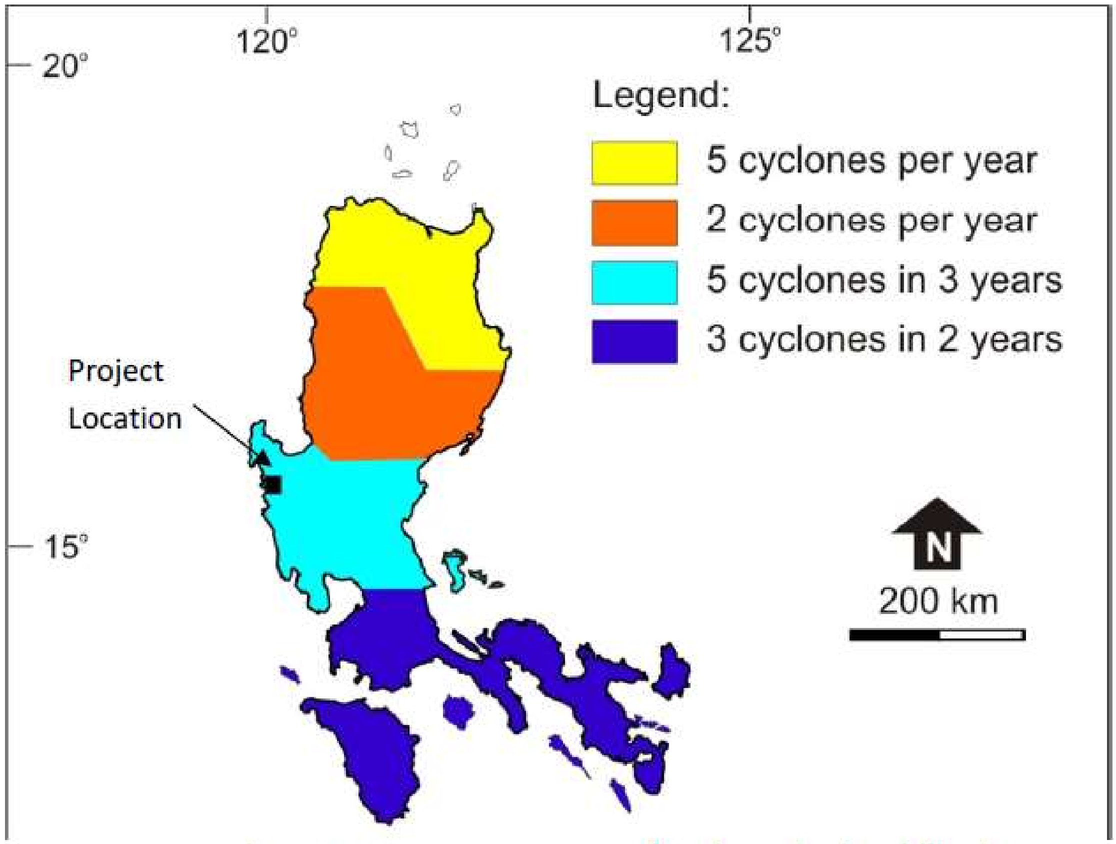


Figure 125 - Frequency Map of Cyclones in the Philippines

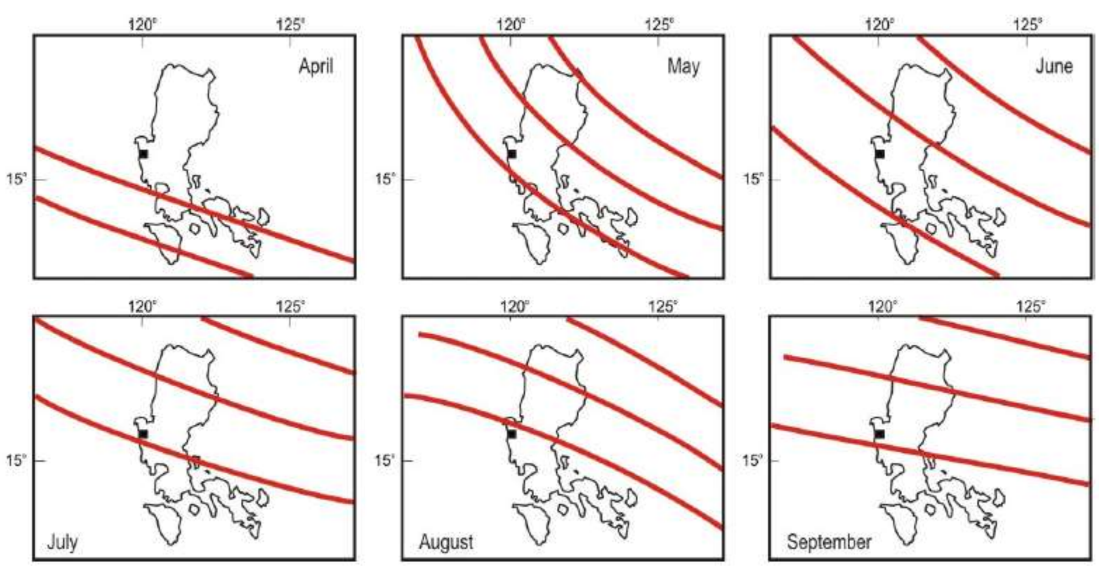


Figure 126 - Normal Tropical Cyclone Paths for the Months of April to September

2.3.2 Air Quality

2.3.2.1 Method of Sampling and Analysis

The methods for sampling and analyses were based from the DENR – EMB Air Quality Monitoring Manual. The results are then compared with the DENR Standards under National Ambient Air Quality Standards (NAAQS) of Republic Act 8749 or known as the Philippine Clean Air Act of 1999.

Table 86 -Methods of Ambient Air Sampling and Analyses

Parameter	Sampling Methodology	Analysis
TSP, Hg, Pb, Cd, As, Cr	High Volume	Filtration Method
PM 10	Dual Channel Dust Sampler	Gravimetric Method
Sulfur Dioxide (SO_2) Nitrogen Dioxide (NO_2)	Personnal Sampler	Absorption in Liquieds for Gaseous Pollutants

Table 87 - Sampling Location (EISWestChinaMin, 2016)

Station	Location
A1	Upwind
A2	Downwind

Table 88 - Sampling Location Candelaria Area

Station	Location	Sampling Date / Time
A1	Barangay Malabon	11-May-18 1651H – 1751H
A2	John Ela Poultry Area	11-May-18 1000H – 11009H
A3	Near Taposo Barangay Hall	11-May-18 1219H – 11319H
A4	Near Reyes Farm	11-May-18 1501H – 1601 H
Standard (NAAQS)		1-hr Sampling

2.3.2.2 Results and Discussion

Table 89 - Air Quality Baseline Results (EISWestChinaMin, 2016)

Station	Location	TSP ug/Ncm	NO2 ug/Ncm	SO2 ug/Ncm	As ug/Ncm	Cd ug/Ncm	Cr ug/Ncm	Pb ug/Ncm	Ni ug/Ncm
A1	Barangay Malabon	12	5.5	8.5	ND	ND	ND	ND	ND
A2	John Ela Poultry Area	15	5.3	7.4	ND	ND	ND	ND	ND
Standard (NAAQS) 24hrs-sampling		**230**	**150**	**180**	**N/A**	**N/A**	**N/A**	**1.5**	**N/A**

Table 90 - Air Quality Baseline Results Candelaria Area

Station	Location	Sampling Date / Time	TSP ug/Ncm	PM10 ug/Ncm	NO2 ug/Ncm	SO2 ug/Ncm	Hg ug/Ncm	Pb ug/Ncm	Cd ug/Ncm	As ug/Ncm	Cr ug/Ncm
A1	Barangay Malabon	11-May-18 1651H – 1751H	22.2	101.8	ND	ND	0.011	ND	ND	ND	ND
A2	John Ela Poultry Area	11-May-18 1000H – 11009H	16.1	81.6	ND	ND	0.012	ND	ND	ND	ND

Station	Location	Sampling Date / Time	TSP ug/Ncm	PM10 ug/Ncm	NO2 ug/Ncm	SO2 ug/Ncm	Hg ug/Ncm	Pb ug/Ncm	Cd ug/Ncm	As ug/Ncm	Cr ug/Ncm
A3	Near Taposo Barangay Hall	11-May-18 1219H – 11319H	48.3	132.1	ND	ND	0.013	ND	ND	ND	ND
A4	Near Reyes Farm	11-May-18 1501H – 1601 H	25.5	91.5	ND	ND	0.009	ND	ND	ND	ND
Standard (NAAQS)		**1-hr Sampling**	**300**	**200**	**260**	**340**	**50**	**20**	**10**	**20**	**N/A**

The air quality within the Sta. Cruz and Candelaria site has minor significant source of air emission that will have an impact at present condition. It is expected that the air emission is far below the DENR Air Quality Guidelines for Criteria Pollutants as per RA 8749 since there were no major activities thatc can affect the quality of air.

2.3.2.3 Greenhouse Gases

A short calculation for the Greenhouse gas (GHG) emission was made using the Gain-Loss (Tier1) method under generic methodologies applicable to multiple land use categories based on Intergovernmental Panel for Climate Change (IPCC) guidelines.

Activities that contribute to the GHG emissions from the operations include carbon loss from stripping, clearing and mining activities and carbon gain from the reforestation during the continuous rehabilitation of the mine site and other activities such as burning of fuels and use of paper products. The carbon from the vehicular emission is still more significant in comparison to losses from the vegetation and soil removal.

Climate Projections in 2020 and 2050 in Region 3

Projections on seasonal temperature increase and rainfall change, and total frequency of extreme events nationally and in the provinces using the mid-range scenario outputs are discussed. A comparison of these values with the high and low range scenarios in 2020 and 2050 is provided in tables. It is to be noted that all the projected changes are relative to the baseline (1971-2000) climate. For example, a projected 1.0oC increase in 2020 in a province means that 1.0oC is added to the baseline mean temperature value of the province. Therefore, if the baseline mean temperature is 27.8oC, then the projected mean temperature in the future is (27.8oC + 1.0oC) or 28.8oC.

In a similar manner, a +25% rainfall change in a province, it means that 25% of the seasonal mean rainfall value in the said province from table of baseline climate is added to the mean value. Thus, if the baseline seasonal rainfall is 900mm, then projected rainfall in the future is 900 mm + 225mm or 1125 mm. This means that we are already experiencing some of the climate change shown in the findings under the mid-range scenario, as we are now into the second decade of the century. The projected seasonal temperature increase, seasonal rainfall change and frequency of extreme events in 2020 and 2050 under the medium-range emission scenario in the provinces in Region 3 are presented in *Table 91* and *Table 93*.

To use the tables and arrive at values of seasonal mean temperature and seasonal rainfall in 2020 and 2050 in any of the provinces, the projections are added to the observed values (presented in each of the tables).

For example, in Zambales, the projected values in 2020 are:

a. DJF mean temperature = (26.3oC + 1.0oC) = 27.3oC

b. DJF rainfall = {40.9+40.9(34.2%)mm} = (40.9+18.9878)mm or 54.8878 mm.

c. Number of days with Tmax > 35oC in Zambales during the 2006-2035 period
(centered at 2020) = 573

d. Number of dry days in Zambales during the 2006-2035 period
(Centered at 2020) = 6500

e. Number of days with rainfall >200mm in Zambales during the 2006-2035 period
(centered at 2020) = 12

Table 91 - Seasonal temperature increase (in °C) in 2020 and 2050 under medium-range

Change In 2020 (2006-2035)	Observed Baseline (1971-2000)				Change In 2020 (2006-2035)				Change In 2020 (2006-2035)			
	DJF	DJF	JJA	SON	DJF	DJF	JJA	SON	DJF	DJF	JJA	SON
Aurora	24.5	27.1	27.9	26.7	0.9	0.9	1.0	1.0	1.9	2.0	2.0	2.0
Bataan	26.4	28.7	27.6	27.3	1.0	1.1	0.8	1.0	2.0	2.1	1.7	1.9
Bulacan	25.6	27.9	27.1	26.7	0.9	1.1	0.9	1.0	1.9	2.1	1.7	1.9
Nueva ecija	25.3	27.7	27.5	26.8	0.9	1.1	0.9	1.0	2.0	2.1	1.8	2.0
Pampanga	26.0	28.3	27.5	27.1	1.0	1.1	0.9	1.0	2.1	2.2	1.8	2.0
Tarlac	26.1	28.3	27.8	27.3	1.1	1.1	0.9	1.0	2.2	2.2	1.9	2.1
Zambales	26.3	28.3	27.4	27.2	1.0	1.1	0.9	1.0	2.1	2.1	1.7	1.9

Source: PAGASA, DOST

Table 92 - Frequency of extreme events in 2020 and 2050 under medium-range scenario in

Change In 2020 (2006-2035)	Observed Baseline (1971-2000)				Change In 2020 (2006-2035)				Change In 2020 (2006-2035)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
Aurora	615.7	546.4	768.7	1151.1	-0.3	-17.1	-4.5	5.8	8.7	-29.2	7.4	-5.7
Bataan	71.7	368.7	1326.2	872.6	2.7	-5.2	9.4	-0.4	-8.2	-8.1	29.1	1.5
Bulacan	212.4	288.9	1041.4	842.1	4.2	-23.0	12.8	-2.9	-13.2	-36.4	23.6	-3.3
Nueva ecija	155.2	316.5	995.0	745.0	7.5	-13.8	10.1	1.6	-7.4	-25.7	22.7	-2.4
Pampanga	120.8	320.6	1030.4	785.2	16.3	-18.8	4.4	-5.1	-15.4	-26.4	13.9	-7.2
Tarlac	43.4	265.4	1193.5	644.3	26.0	-13.7	-1.6	-9.6	-6.7	-18,2	8.8	-5.5
Zambales	40.9	368.0	1793.9	872.0	34.2	-4.5	13.3	-1.6	-2.2	-21.6	31.4	5.6

Source: PAGASA, DOST

Table 93 - Frequency of extreme events in 2020 and 2050 under medium-range scenario in

Region 3	Stations	No. of Days w/ Tmax >35oC			No. of Days w/ Tmax >35oC			No. of Days w/ Rainfall >200mm		
		OBS (1971-2000)	2020	2050	OBS	2020	2050	OBS	2020	2050
Aurora	Baler	397	819	2008	1295	6176	6161	12	43	43
Nueva ecija	Cabanatuan	1293	3271	4796	8113	6117	6202	9	13	17
Pampanga	Clark	355	1855	3108	889	5701	5754	8	12	12
Zambales	Iba	259	573	1573	8034	6500	6325	4	12	13

Source: PAGASA, DOST

2.3.2.3.1 Seasonal Temperature Change

All areas of the Philippines will get warmer, more so in the relatively warmer summer months. Mean temperatures in all areas in the Phils. are expected to rise by 0.9oC in 2020 and by 1.8oC to 2.2oC in 2050. Likewise, all seasonal mean temperatures will also have increases in these time slices; and these increase during the four seasons are quite consistent in all parts of the country. In Zambales, the largest temperature increase is projected during the summer (MAM) season in 2020 and December to May in 2050 based on *Table 91*.

2.3.2.3.2 <u>Seasonal Rainfall Change</u>

Generally, there is reduction in rainfall in most parts of the country during the summer (MAM) season. However, rainfall increase is likely during the southwest monsoon (JJA) season until the transition (SON) season in most areas of Luzon and Visayas, and also during the northeast monsoon (DJF) season, particularly, in provinces/areas characterized as Type II climate in 2020 and 2050. There is however, generally decreasing trend in rainfall in Mindanao, especially by 2050.

There are varied trends in the magnitude and direction of the rainfall changes, both in 2020 and 2050. What the projections clearly indicate are the likely increase in the performance of the southwest and the northeast monsoons in the provinces exposed to these climate controls when they prevail over the country. Moreover, the usually wet seasons become wetter with the usually dry seasons becoming also drier; and these could lead to more occurrence of floods and dry spells/droughts, respectively. In Zambales, more rains will be expected during the months of December to February in 2020, while in 2050, it will be experienced during the months of June to August as shown in *Table 91*.

2.3.2.3.3 <u>Extreme Temperature Events</u>

Hot temperatures will continue to become more frequent in the future*Table 91* shows that the number of days with maximum temperature exceeding 35ºC (following value used by other countries in the Asia Pacific region in extreme events analysis) is increasing in 2020 and 2050.

2.3.2.3.4 <u>Extreme Rainfall Events</u>

Heavy daily rainfall will continue to become more frequent, extreme rainfall is projected to increase in Luzon and Visayas only, but number of dry days is expected to increase in all parts of the country in 2020 and 2050. In Zambales, number of days with rainfall more than 200mm will increase by more than 300% than observed in 2020 & 2050 based on *Table 93* projections.

2.3.3 Noise Quality

Table 94 - Observed 1-hr Noise Level Propagation in Decibels dB(A) at Station A1 - Barangay Malabon

Sampling Time	dB (A)	Remarks	Sampling Time	dB (A)	Remarks
17:09:00	46.8$^{(D)}$	Within	17:40:12	49.1$^{(D)}$	Within
17:10:12	46.8$^{(D)}$	Within	17:41:24	49.6$^{(D)}$	Within
17:11:24	45.9$^{(D)}$	Within	17:42:36	49.8$^{(D)}$	Within
17:12:36	45.8$^{(D)}$	Within	17:43:48	43.9$^{(D)}$	Within
17:13:48	46.7$^{(D)}$	Within	17:45:00	43.6$^{(D)}$	Within
17:15:00	46.7$^{(D)}$	Within	17:46:12	43.7$^{(D)}$	Within
17:16:12	46.9$^{(D)}$	Within	17:47:24	43.9$^{(D)}$	Within
17:17:24	46.2$^{(D)}$	Within	17:48:36	48.7$^{(D)}$	Within
17:18:36	49.0$^{(D)}$	Within	17:49:48	49.1$^{(D)}$	Within
17:19:48	48.9$^{(D)}$	Within	17:51:00	48.2$^{(D)}$	Within
17:21:00	49.0$^{(D)}$	Within	17:52:12	48.7$^{(D)}$	Within
17:22:12	49.1$^{(D)}$	Within	17:53:24	43.8$^{(D)}$	Within
17:23:24	49.5$^{(D)}$	Within	17:54:36	43.8$^{(D)}$	Within
17:24:36	56.5$^{(D)}$	Within	17:55:48	42.9$^{(D)}$	Within
17:25:48	56.7$^{(D)}$	Within	17:57:00	43.8$^{(D)}$	Within
17:27:00	55.6$^{(D)}$	Within	17:58:12	43.2$^{(D)}$	Within
17:28:12	56.5$^{(D)}$	Within	17:59:24	43.9$^{(D)}$	Within
17:29:24	44.8$^{(D)}$	Within	18:00:36	43.8$^{(E)}$	Within
17:30:36	44.9$^{(D)}$	Within	18:01:48	43.1$^{(E)}$	Within
17:31:48	43.9$^{(D)}$	Within	18:03:00	43.2$^{(E)}$	Within
17:33:00	45.6$^{(D)}$	Within	18:04:12	40.4$^{(E)}$	Within
17:34:12	48.5$^{(D)}$	Within	18:05:24	40.3$^{(E)}$	Within
17:35:24	48.5$^{(D)}$	Within	18:06:36	40.9$^{(E)}$	Within
17:36:36	47.9$^{(D)}$	Within	18:07:48	42.5$^{(E)}$	Within
17:37:48	48.2$^{(D)}$	Within	18:09:00	42.6$^{(E)}$	Within
17:39:00	49.0$^{(D)}$	Within			
DENR Standard* (NPCC)		**65$^{(D)}$**		**60$^{(E)}$**	

*Noise standard for Class "B" (Commercial Area; D = Daytime, E = Evening Time)

Table 95 - Observed 1-hr Noise Level Propagation in Decibels dB(A) at Station A2 - John Ela Poultry Area

Sampling Time	dB (A)	Remarks	Sampling Time	dB (A)	Remarks
10:37:00	58.4	Within	11:08:12	56.1	Within
10:38:12	58.0	Within	11:09:24	56.9	Within
10:39:24	58.6	Within	11:10:36	56.7	Within
10:40:36	58.9	Within	11:11:48	62.9	Within
10:41:48	***65.7***	Exceeded	11:13:00	62.8	Within
10:43:00	***65.8***	Exceeded	11:14:12	62.3	Within
10:44:12	65.0	Within	11:15:24	62.1	Within
10:45:24	***65.7***	Exceeded	11:16:36	59.8	Within
10:46:36	55.0	Within	11:17:48	59.1	Within
10:47:48	55.9	Within	11:19:00	59.7	Within
10:49:00	55.6	Within	11:20:12	59.8	Within
10:50:12	55.8	Within	11:21:24	48.1	Within
10:51:24	55.9	Within	11:22:36	48.6	Within
10:52:36	64.4	Within	11:23:48	48.9	Within
10:53:48	64.9	Within	11:25:00	48.2	Within
10:55:00	64.8	Within	11:26:12	47.4	Within
10:56:12	64.7	Within	11:27:24	47.6	Within
10:57:24	42.8	Within	11:28:36	47.8	Within
10:58:36	42.7	Within	11:29:48	47.2	Within
10:59:48	42.3	Within	11:31:00	59.7	Within
11:01:00	42.9	Within	11:32:12	59.6	Within
11:02:12	43.1	Within	11:33:24	59.1	Within
11:03:24	43.6	Within	11:34:36	59.8	Within
11:04:36	43.9	Within	11:35:48	49.9	Within
11:05:48	43.7	Within	11:37:00	49.7	Within
11:07:00	56.2	Within			
DENR Standard* (NPCC)			**65**		

*Noise standard for Class "B" (Commercial Area, Daytime)

Table 96 - Observed 1-hr Noise Level Propagation in Decibels dB(A) at Station 3 - Near Taposo Barangya Hall

Sampling Time	dB (A)	Remarks	Sampling Time	dB (A)	Remarks
12:52:00	***71.3***	Exceeded	13:23:12	53.7	Within
12:53:12	***72.9***	Exceeded	13:24:24	53.8	Within
12:54:24	***71.6***	Exceeded	13:25:36	48.9	Within
12:55:36	***71.8***	Exceeded	13:26:48	48.6	Within
12:56:48	46.7	Within	13:28:00	48.1	Within
12:58:00	46.9	Within	13:29:12	48.7	Within
12:59:12	46.8	Within	13:30:24	48.5	Within
13:00:24	46.2	Within	13:31:36	48.6	Within
13:01:36	53.9	Within	13:32:48	48.8	Within
13:02:48	54.6	Within	13:34:00	49.7	Within
13:04:00	54.8	Within	13:35:12	52.6	Within
13:05:12	55.9	Within	13:36:24	54.6	Within
13:06:24	48.2	Within	13:37:36	54.6	Within
13:07:36	48.3	Within	13:38:48	50.3	Within
13:08:48	48.1	Within	13:40:00	50.6	Within
13:10:00	48.7	Within	13:41:12	51.6	Within
13:11:12	55.7	Within	13:42:24	50.6	Within
13:12:24	55.6	Within	13:43:36	50.9	Within
13:13:36	55.1	Within	13:44:48	57.2	Within
13:14:48	55.9	Within	13:46:00	57.9	Within
13:16:00	58.3	Within	13:47:12	57.8	Within
13:17:12	58.9	Within	13:48:24	57.6	Within
13:18:24	59.8	Within	13:49:36	48.0	Within
13:19:36	***60.6***	Exceeded	13:50:48	48.1	Within
13:20:48	53.4	Within	13:52:00	48.9	Within
13:22:00	53.6	Within			
DENR Standard* (NPCC)			**60**		

*Noise standard for Class "A" (Residential Area, Daytime)

Table 97 - Observed 1-hr Noise Level Propagation in Decibels dB(A) at Station 4 - Near Reyes Farm

Sampling Time	dB (A)	Remarks	Sampling Time	dB (A)	Remarks
15:27:00	40.0	Within	15:58:12	48.6	Within
15:28:12	42.3	Within	15:59:24	48.9	Within
15:29:24	40.9	Within	16:00:36	53.9	Within
15:30:36	40.7	Within	16:01:48	53.6	Within
15:31:48	43.5	Within	16:03:00	53.8	Within
15:33:00	43.6	Within	16:04:12	54.8	Within
15:34:12	43.7	Within	16:05:24	49.2	Within
15:35:24	43.9	Within	16:06:36	48.7	Within
15:36:36	39.6	Within	16:07:48	49.7	Within
15:37:48	39.7	Within	16:09:00	49.1	Within
15:39:00	39.8	Within	16:10:12	48.9	Within
15:40:12	40.3	Within	16:11:24	48.1	Within
15:41:24	45.1	Within	16:12:36	48.5	Within
15:42:36	45.8	Within	16:13:48	48.3	Within
15:43:48	45.6	Within	16:15:00	52.7	Within
15:45:00	46.1	Within	16:16:12	53.6	Within
15:46:12	42.5	Within	16:17:24	52.7	Within
15:47:24	42.8	Within	16:18:36	52.6	Within
15:48:36	42.3	Within	16:19:48	50.6	Within
15:49:48	43.7	Within	16:21:00	51.6	Within
15:51:00	59.8	Within	16:22:12	50.7	Within
15:52:12	59.6	Within	16:23:24	50.8	Within
15:53:24	59.8	Within	16:24:36	44.4	Within
15:54:36	58.7	Within	16:25:48	46.5	Within
15:55:48	46.3	Within	16:27:00	44.8	Within
15:57:00	47.9	Within			
DENR Standard* (NPCC)			65		

*Noise standard for Class "B" (Commercial Area, Daytime)

Table 94 and *Table 97* presents the results of noise level monitoring recorded in decibel dB(A). The results are compared with the DENR Ambient Noise Quality Standards Sec. 78 Chapter IV, Article 1 of National Polllution Control Commission (NPCC) Rules and Regilations, 1978 standard limits for class A and B category.

The summary of the result for the four sampling stations are as follows:

Station Name/Description	Result/Conclusion
Station A1 Barangay Malabon	All time Passed the DENR Standard
Station A2 John Ela Poultry Area	Three (3) time division Exceeded the DENR Standards
Station A3 Near Taposo Barangay Hall	Five (5) time divisions Exceeded the DENR Standards

Station Name/Description	Result/Conclusion
Startion A4 Near Reyes Farm	All time divisions POassed the DENR Standard

2.3.4 Impact Assessment and Mitigating Measures

2.3.4.1 Impacts on Air Quality and Ambient Noise

Activities during construction and operation phases of the Project that may have potential impact on air quality include land clearing, extraction, processing and hauling of ores. These activities may cause intermittent increase in suspended particulate matter concentrations especially during hot and windy days. Vehicular emissions and operation of equipment generate gaseous pollutants and particulate matter that have potential impact on health. Mining and processing workers/personnel are the most probable receptors of gaseous emissions and dust generated by the Project. On the other hand, noise from vehicles, equipment and processing plant could cause stress and nuisance to existing fauna and to communities living near the haul roads. Noise and other hazardous sound can also cause hearing impairment to mine workers and/or disrupt certain body functions.

2.3.4.2 Mitigating Measures

Impacts on air quality shall be addressed through the following:

- Watering/dampening of roads to minimize the dust generated from hauling of ores
- Proper scheduling of ore extraction and hauling (i.e. minimization of hauling activities during periods of high wind velocity; scheduling of noisy activities during daytime)
- Phasing of mining activities (to minimize exposed areas)
- Preventive maintenance of processing plant, equipment and vehicles
- Imposition of speed limits along access roads (30 kph maximum)
- Provision of covers and mufflers for haul trucks
- Installation, proper operation, and maintenance of the CEMS
- Proper monitoring at the off-site ambient air quality monitors
- Conduct validation air dispersion modelling

Noise generated shall be addressed through the following:

- Proper scheduling of ore extraction, and hauling (i.e. scheduling of noisy activities during daytime)
- Preventive maintenance of plant, equipment and vehicles

- Enclosure of equipment emitting high level noise (when applicable)

Detrimental effects on mining personnel's health shall be mitigated by providing protective gears or personal protective equipment (PPE) such as masks and ear plugs.

2.4 People

2.4.1 Displacement of Settlers

2.4.1.1 Demography

2.4.1.1.1 Population (Municipality)

The 2015 NSO Census recorded that Sta. Cruz has a total population of 58,151 composed of 9,754 households, while Candelaria has 31,386 with 5,491 households. *Table 98* shows the total population and households of both municipalities.

Table 98 - Population of the Municipalities of Sta. Cruz and Candelaria

Municipality	Population (Year)	Household
Sta. Cruz	58,151	9,754
Candelaria	31,386	5,491
TOTAL	**89,537**	**15,245**

In 2015, Sta. Cruz has lower annual growth rate of 1.54% compared to 2.98% for Candelaria. *Table 99* shows the population history of both Sta. Cruz and Candelaria.

Table 99 - Population History of the Municipalities of Sta. Cruz and Candelaria

Year	Municipality			
	Sta. Cruz		Candelaria	
	Population	Annual Growth Rate (%)	Population	Annual Growth Rate (%)
2000	49,269	2.43	23,399	2.94
2007	52,269		24,243	

Year	Municipality			
	Sta. Cruz		Candelaria	
	Population	Annual Growth Rate (%)	Population	Annual Growth Rate (%)
2015	58,151	1.54	31,386	2.98

2.4.1.1.2 Population of Impact Barangays

The nine (9) project-impact barangays have a total population of 20,723 individuals representing 5,655 households. Refer to Table 7 for the breakdown of population and households per barangay and Table 8 for the distribution of population by gender.

Table 100 - Population of 8 Project-Impact Barangays

Barangay	Population	Household
Guinabon	1,565	384
Lauis	2,309	429
Malabon	3,155	765
Malimanga	1,419	551
Pamibian	1,539	278
Pinagrealan	1,416	220
Sinabacan	3,915	1,015
Taposo	1,225	235
Uacon	4,180	783
TOTAL	**20,723**	**5,655**

Table 101 - Population by Gender in 8 Project-Impact Barangays

Barangay	Number of House holds	Population		
		Male	Female	Total
Guinabon	384	801	764	1,565
Lauis	429	1153	1156	2,309

Barangay	Number of House holds	Population		
		Male	Female	Total
Malabon	846	1564	1591	3,155
Malimanga	243	698	721	1,419
Pamibian	308	857	682	1,539
Pinagrealan	267	733	683	1,416
Sinabacan	760	1967	1948	3,915
Taposo	234	628	597	1,225
Uacon	2,184	2064	2116	4,180
TOTAL	5,655	10,465	10,258	20,723

2.4.1.1.3 Ethnicity and Language

Major ethnic groups are sambal, ilocano and pangasinense. Majority of the population speaks sambal. The second major language spoken are tagalog and Ilocano.

2.4.1.1.4 Land Area and Usage

The municipality of Sta. Cruz has a total land area of 41,404 hectares, which constitutes 11.14% of the total land area of the Province of Zambales. It has a total urban area of 220 hectares which is subdivided into three (3) areas, Barangay Poblacion North, Barangay Poblacion South and Barangay Lipay. The other twenty-two (22) barangays are classified as rural areas.

Of the total land area of 41,404 hectares of the municipality of Sta. Cruz, 67% or 27,687 hectares have been classified as public forest. About 12,515 hectares are considered alienable and disposable lands. About 887 hectares are proposed industrial areas or ecozones. Timberland areas constitute 5,432 hectares. Forest reserves, which is set aside as watershed, covers 7,800 hectares and 1,208 hectares is set aside as civil reservation.

The municipality of Candelaria has a total land area of 33,359.19 hectares. Majority of which are classified as forestlands. Built up spaces are classified as residential as well as for other purposes like industrial and commercial establishments. Currently, the municipality is in the process of updating its CLUP. *Table 102* summarizes the land uses of both municipalities.

Table 102 - Area and Landuses of Candelaria and Sta. Cruz

Land Use	Candelaria	Sta. Cruz	TOTAL
Agricultural	2,523.67	4,292.00	6,815.67
Industrial	0.00	18.00	18.00
Commercial	0.00	50.00	50.00
Residential	4,742.83	2,750.00	7,492.83
Institutional	0.00	20.00	20.00
Open space	26,092.69	5,402.69	31,495.38
Others	0.00	31,313.31	31,313.31
TOTAL	**33,359.19**	**41,404.00**	**77,205.19**

A significant portion of the area of both municipalities are used for mineral production.

2.4.1.1.5 Education

Sta. Cruz has 27 public elementary schools distributed in all barangays comprised of 81 school buildings with 232 classrooms. The total area of public elementary school compound is 23.5 hectares, of which 2.382 hectares is allotted for playground area. For secondary education, it has 8 public high schools with a total of 64 classrooms situated in 6 thickly populated barangays on combined school compound of 7 hectares. The lone private high school is located in the heart of the town, in Poblacion South, has 34 classrooms on a 7,480 square meters of school compound which also include 1,531 square meters for playground.

Tertiary schools present are the Columban College in Barangay Naulo and the Macro Asia College in Poblacion. For those who cannot afford to pursue college education, there is an on-the-job training on different vocational courses being offered through the cooperative efforts of different government agencies, specifically supervised by the TESDA. While education for pre-schoolers is under the auspices of MSWD Office in cooperation with concerned barangay officials and parent's committee through day-care services.

2.4.2 In-migration

2.4.2.1 Housing

Majority of the housing (84%) are single type. Duplex type is only about 4%, while 11% are barong-barong type. 52% are made of concrete. 34% are made of mixed concrete and wood. 9% are made of bamboo and nipa, while 5% are made of wood. About 77% of roofing are made of GI sheet. About 12% are made of nipa and cogon, 8% are made of concrete and 3% are teguila tiles. Refer to *Table 103 Table 104* and *Table 105*.

Table 103 - Housing in 9 Project-Impact Barangays

Barangay	Number per type of Structures				
	Single	Duplex	Apartment	Barong.barong	Total
Guinabon	373	1	0	10	384
Lauis	321	19	0	39	379
Malabon	752	2	4	86	844
Malimanga	155	7	0	74	236
Pamibian	220	3	0	25	248
Pinagrealan	0	0	0	0	0
Sinabacan	783	103	7	121	1014
Taposo	0	0	0	0	0
Uacon	0	0	0	0	0
TOTAL	**2604**	**135**	**11**	**355**	**3105**

Table 104 - Housing Materials in 9 Project-Impact Barangays

Barangay	Number per Type of Housing Materials				
	Concrete	Wood	Mixed Wood & Concrete	Bamboo/Nip a	Total
Guinabon	313	41	22	8	384
Lauis	216	17	121	24	378

Barangay	Number per Type of Housing Materials				
	Concrete	Wood	Mixed Wood & Concrete	Bamboo/Nip a	Total
Malabon	196	93	473	84	846
Malimanga	94	0	112	37	243
Pamibian	68	11	136	32	247
Pinagrealan	0	0	0	0	0
Sinabacan	685	0	165	100	950
Taposo	0	0	0	0	0
Uacon	0	0	0	0	0
TOTAL	**1,572**	**162**	**1,029**	**285**	**3,048**

Table 105 - Roofing Materials in 9 Project-Impact Barangays

Barangay	Number per Type of Roofing Materials				
	G.I	Concrete	Nipa/Cogon	Tegula Tiles	Total
Guinabon	375	0	9	0	384
Lauis	357	17	15	0	389
Malabon	359	223	162	102	846
Malimanga	204	1	37	1	243
Pamibian	243	1	29	1	274
Pinagrealan	0	0	0	0	0
Sinabacan	888	0	142	0	1,030
Taposo	0	0	0	0	0
Uacon	0	0	0	0	0
TOTAL	**2,426**	**242**	**394**	**104**	**3,166**

2.4.3 Ancestral Domain Claim

As per records kept on file in CENRO, Masinloc, Zambales, it showed that there are no ancestral domain claims within the project area.

2.4.4 Impacts on Physical Cultural Resources

There are no physical cultural resources and landscapes that have archeologic, paleontologic, historical, religious, aesthetic or cultural significance in the project area.

2.4.5 Threat to delivery of basic services

2.4.5.1 Water Supply

In Sta. Cruz, most of the residents of poblacion rely on Sta. Cruz Water District on their need for potable water supply. The source of water of this district are two (2) deep wells located in Poblacion North with a water pump having a capacity of 5 LPS and on a 14-hour daily operating time. It has 100-cubic meter water tank in Barangay Bulawon. All other barangay residents draw water supply mostly from deep and shallow wells, except Barangay Babuyan and Sitio Acoje, Mapalad, Ballag and Pine Tree of Barangay Lucapon South whose source of water are springs.

In Candelaria, Ten (10) out of 16 barangays are being served by the Candelaria Water districts (CWD) installed at Barangays Babancal, Catol, Libertador, Malabon, Malimanga, Panayunan, Pamibian, Poblacion, Sinabacan, Uacon. Aside from the CWD, the remaining six (6) barangays depend on open well, pitcher type, jetmatic pump, artesian well, lake and rain water as the major source of water supply in the community. These water sources are extensively used for domestic and industrial uses.

2.4.5.2 Access to Clean Water (Impact Barangays)

About 63% of the household in the project-impact barangays sourced their water through jetmatic pumps, 18% through level III water system (municipal water system and communal water system), 15% on level II water system, 2% on artesan well and 1% on open well.

Table 106 - Access to clean water (Impact Barangays)

Barangay	Number of Household per Type of Facilities						
	Level III (communal water system)	Level II (individual household distribution	Artesian well	Jetmatic pump	Open well	Others	Total
Guinabon	0	0	0	200	0	0	200
Lauis	15	0	0	467	0	96	578
Malabon	0	296	12	355	11	0	674
Malimanga	0	0	40	110	0	150	300
Pamibian	98	0	0	198	0	0	296
Pinagrealan	0	0	0	0	0	0	0
Sinabacan	87	63	0	82	15	0	247
Taposo	0	0	5	117	0	0	122
Uacon	0	0	0	0	0	0	0
TOTAL	**200**	**359**	**57**	**1,529**	**26**	**246**	**2,417**

2.4.5.3 Power Supply

The electricity in the municipalities of Candelaria and Sta. Cruz is provided by Zambales Multi-Purpose Electric Cooperative (ZAMECO).

2.4.5.4 Access to Energy and Fuel (Impact Barangays)

Majority of the households in these barangays have access to electricity. About 120 households sourced their energy needs through the use of kerosene.

About 67% of the households used LPG for their fuel needs. 16% still used firewoods, 8% used charcoal and 8% kerosene. Only 1% used electricity for their fuel needs.

2.4.5.5 Communication

In Sta. Cruz, the delivery of mails, goods and monetary articles are being taken care of by the Philippine Postal Corporation and LBC. There is a radio communication system used primarily by the different government agencies with one line linking all municipalities of the province and another line connects all barangays of the municipality. A landline telephone system already exists in Sta. Cruz operated by DIGITEL providing such services and conveniences of national and international direct calls.

Mobile telephone system provided to both municipalities by Smart Telecommunication and Globe Telecommunication.

2.4.6 Threat to public health and safety

2.4.6.1 Health

Sta. Cruz has one government-run hospital, the Medicare Community Hospital. This medical facility caters to the municipality's less privileged residents. lt is a 26-bed capacity hospital with two (2) doctors, three (3) nurses, one (1) medical technologist, three (3) midwives and ten (10) support staff. The municipal government also has at its disposal two (2) rural health units (RHUs) located at Barangays Poblacion South and Bayto. The RHUs are manned by one (1) Physician, two (2) nurses, one (1) dentist, one (1) medical technologist, two (2) sanitary inspectors and ten (10) midwives - four (4) for RHU L and six (6) for RHU 2. The municipality's health services and facilities appear to be inadequate to deliver sufficient care to the municipality's populace. This is supplemented by the presence of private hospitals and clinics. There are nine (9) private health facilities present in Sta. Cruz with a combined medical force of thirteen (13) doctors and two (2) nurses.

The municipality of Candelaria has also one government-run hospital, the Candelaria District Hospital, with a twenty-four (24) bed capacity. The increase in population has not resulted in a corresponding increase in hospital beds. A Rural Health Unit (RHU) is also maintained by the municipality located in Barangay Poblacion. The RHU is manned by a Municipal Health Officer with one (1) Public Health Dentist, six (6) Rural Health Midwifes, three (3) Public Health Nurses, a Medical Technologist, a Sanitary Inspector, a Dental Aide, and a Laboratory Aide. There are also 213 Barangay Health Workers spread across the 16 Barangays to provide First Aid. A number of Barangays have their own Barangay Health Center, which are regularly visited by the personnel from the RHU. The ambulance owned by the LGU is usually tapped to transport patients not only to the Provincial Hospital, but also to the more modern hospitals in Olongapo City, Dagupan City and/or to Manila. Midwives play an essential role in the delivery of public health services.

Table 107 - Health Manpower in Candelaria, 2016

Manpower	Number
Municipal Health Officer	1
Public Health Dentist	1
Public Health Nurses	3
Rural Health Midwives	6
Medical Technologist	1
Rural Sanitation Inspector	1
Dental Aide	1
Nurse Deployment Program	9
Rural Health Midwife Placement Program	2
Public Health Associate	1
Encoders	2
Pharmacy Aide	1
Laboratory Aide	1
Utility	2
Barangay Health Workers	213
Total	**245**

The population-midwife ratio in Sta. Cruz and Candelaria was 1:4,478 and 1:3,832 respectively.

In the municipality of Candelaria, the ten (10) leading causes of morbidity across all ages in 2016 are the acute respiratory infection, dental abcess, hypertension, fever/headache, bronchial asthma, urinary tract infection, diabetes metilus, wound abcess, skin diseases or allergies and wound.

Table 108 - Leading Causes of Morbidity in Candelaria, 2016

Causes	Number	Rate/10,000 POP
Acute Respiratory Infection	4,399	1,698
Dental Abcess	1,980	764
Hypertension	1,665	643
Fever/Headache	1,481	572
Bronchial Asthma	946	365
Urinary Tract Infection	565	218
Diabetes Mellitus	387	149
Wound Abcess	361	139
Skin Disease/Allergy	349	135
Wound	347	134

The leading causes of mortality across all ages in the municipality of Candelaria in 2016 are disease of the vascular system/SCVD/brain stroke, respiratory failure/pneumonia, cancer all forms, multi organ system failure, respiratory failure/status ashmaticus/COPD, disease of the heart/M.I, acute renal failure/diabetes mellitus and respiratory failure.

Table 109 - Leading Causes of Mortality in Candelaria, 2016

Causes	Number	Rate/10,000 POP
Disease of the Vascular System/SCVD/Brain Stroke	27	10
Respiratory Failure/Pneumonia	25	10
Cancer all forms	24	9
Multi Organ System Failure	11	4
Respiratory Failure/Status Ashmaticus/COPD	8	3
Disease of the Heart/M.I	7	3
Acute Renal Failure/Diabetes Melitus	6	2
Respiratory Failure. Kidney Disease	5	2

Causes	Number	Rate/10,000 POP
Respiratory Failure. PTB	3	1
Repiratory Failure. Electric Shock	1	1

There were a total of 454 live births in the Municipality of Candelaria in 2016, with 5 cases of infant deaths within the same year. The crude birth rate of the municipality is 175/10,000 pop. The crude death rate is 51/10,000 pop. The infant death rate is 11/1,000 pop. The neonatal death rate is 7/1,000 live births. The maternal death rate is 0/1,000 live births. The fedal death rate is 9/1,000 live births.

The leading infant and neonatal mortality in the municipality of Candelaria in 2016 is severe pneumonia, prematurity and congenital anomaly.

2.4.6.2 Health Services and Facilities (Impact Barangays)

There are about 14 health related facilities in the project-impact barangays, in which majority are barangay health stations or barangay health centers, nutrition posts and botika sa barangay or drugstores. Refer to Table 12. These facilities is manned by 90 health workers, of which 81 are barangay health workers (BHWs) and 9 are barangay nutrition scholars (BNS). Refer to *Table 110*.

Table 110 - Health Facilities in 9 Project-Impact Barangays

	Number of Health Facilities per Barangay									
	Guinabon	Lauis	Malabon	Malimanga	Pamibian	Pinagrealan	Sinabacan	Taposo	Uacon	Total
Health station	1	1	1	1	1	1	1	0	1	8
Drugstore	0	1	0	0	1	0	1	0	0	3
Hospital	0	0	0	0	0	0	0	0	0	0
Nutrition Center	0	0	1	1	1	0	0	0	0	3
Private Clinic	0	0	0	0	0	0	0	0	0	0
Total	**1**	**2**	**2**	**2**	**3**	**1**	**2**	**0**	**1**	**14**

2.4.7 Generation of Local Bebefits from the Project

2.4.7.1 Farming

The municipality of Sta. Cruz is primarily an agricultural town. About 11.59% of its total land area or 5,082.85 hectares is devoted to agriculture. Of this figure, about 3,503.85 hectares are planted to palay, which is the major crop of the municipality. Next to palay, mango is also a major commercial product.

In addition, the land area utilized for corn production is about 90 hectares. It produces a total of 379 and 7 metric tons of yellow and white corn, respectively. The land area devoted to vegetables and root crops is about 496 hectares. Sta. Cruz is sufficient in ampalaya, eggplant, tomatoes, squash, pechay, gabi, pole sitaw, peanut, cassava and camote. Other fruit crops produced include coconut, guyabano, banana, guava and calamansi.

In municipality of Candelaria, there are 923 active and full-time farmers engaged in farming in an arable area of 1,673 hectares of irrigated and non-irrigated (rain-fed areas devoted to rice planting. A total of 1,044 hectares is irrigated by communal irrigation and by power and 629 is rain-fed or non-irrigated. Average production per record from the office of the agriculture services is 85 cavans per hectares; consumption is 58,460 cavans giving a consumption rate per person of 117 kilograms a year. Some 53,496 hectares of arable lands are planted with mangoes, coconuts, citrus, sugarcane root crops and vegetables.

2.4.7.2 Fishery

In municipality of Sta. Cruz, the marine water serves as a wider fishing area the fish and crustaceans caught are alimasag, alumahan, anglat, babayote, bagsang, bakalaw, balake, bangus, baral, batalay, baya-baya, bisugo, bondying, bonito, borador, dalagang bukid, dilis, dorado, galunggong, gulyasan, hasaan, hasa-hasa, hipon, igat, imoy, kilong kilong, kulangutan, labahita, lapu-lapu, lobster, loro, lugso, malasugi, mamalaki, margar,mataan, matambaka, maya-maya, mayubyob, molmol, monamon, oriles, padas, pagi, palos, papakol, pating, pingka, pugita, pusit, salay-salay, samara, sapsap, sarmolyete, siriw, susay, talakitok, talangka, talang-talang, tambakol, tamban, tanigue, tarian, tirong, titong, tulingan, tuna and uwak. In addition to these and with regards to in-land fishing, there are a total of 400.7 hectares of fishpond situated in 12 barangays which are adjacent to one another.

In municipality of Candelaria, a total fish production of 769 metric tons from 163 hectares of brackish water, while a freshwater fishery of 4.6 hectares produced 3 metric tons of fish.

2.4.7.3 Livestock & Poultry

In municipality of Sta. Cruz, the produced livestock and poultry are 1,386 cattle, 1,163 water buffalo (carabao), 10,065 swines, 595 goats, 36,766 chicken, 216 pigeons and 385 ducks.

In municipality of Candelaria, there are 14,750 livestock population in the community as per last survey conducted such as 8,000 chickens, 1,500 swines, 1,100 water buffalo, 1,700 cows, 200 ducks and 2,100 goats.

2.4.7.4 Labor Availability and Distribution

In municipality of Candelaria, a labor force of 10,231 individuals, representing 15 years old and above of the population. Of this figure, 9,054 individuals belong to the economically active group. Only about 33.69% are employed. Agriculture accounts the biggest number of employment with 1,242 individuals, followed by industry, manufacturing and mining with 1,563 individuals, and services with 611 individuals.

2.4.7.5 Family Income

As reflected in the integrated coastal management plan of Sta. Cruz, the municipality has an estimated average household income of PhP 30,000. In municipality of Candelaria, an estimated average family income of Php 40,000.

2.4.7.6 Municipal Income

Sta. Cruz is considered as a first-class municipality, while Candelaria is considered a third class municipality.

2.4.7.7 Trade and Commerce

The municipality of Sta. Cruz is now considered as a commercial center in northern Zambales due to the presence of Magic Mall and different types of business establishments where almost fifty percent comes from wholesale and retail trade sector, a great number of which are sari-sari stores. These are mostly situated within Sta. Cruz Public Market, the biggest public market in the Province of Zambales whose main building houses a total of 466 stalls. Aside from this, there are two buildings for fruits and vegetables section, and the pastry section of the public market. In addition, there is an area designated as hawker's area or an area allotted to transient vendors.

Different types of business establishments are also situated adjacent to the public market and along the national highway ranging from agricultural supply dealers, hardware stores, drugstores, etc. Sari-sari stores abound in the different barangays providing merchandise needed for day to day livelihood in their immediate area.

There are also small and/or cottage industries such as ice plant, concrete hollow block factory, bagoong and vinegar making, palay thresher fabrication, fabrication of tricycle's side car, etc. Most of these establishments were organized as single proprietorship and were not capital nor labor intensive business ventures as some of them do not hire employees but for unpaid family workers. Raw materials used are locally available while their finished products are sold within the municipality and to adjacent towns. Other industrial activities are mostly agro-based like piggery, poultry raising and rice mills.

In municipality of Candelaria, there are a total of 165 business/merchants engaged in various kinds of commercial activities from retail merchandising, in buying and selling of various merchandise and commodities with total investment of Php 1,648,677.30. This number of business establishment is way below the 505 business enterprises operated. Majority of these establishments are sari-sari stores, vegetable dealers, vulcanizing shops, rice dealers, refreshment parlors, dry goods, meat dealers, agricultural supply, drugstores, construction supply, gasoline stations, tricycle/bicycle spare parts shops, Xerox and school supplies, funeral parlors, beauty shop, electronic shop, welding shop, studio and optical shop. Other industries present are bagoong and salt making, bakeries, pastillas making, concrete product making, tailoring, metal crops, furniture making, dress shop and rice mills.

2.4.7.8 Transport, Market and Credit Facilities

The produce for the both municipalities are being marketed on different location depending on their classifications. Dry goods such as RTWs, glasswares, school supplies, shoes, accessories, gadgets and hardware supplies are being produced from Luzon Region especially in NCR. For wet goods such as fish, meat and vegetables products are procured locally in the province, NCR and Baguio City.

2.4.7.9 Cooperatives and other organization

There are about twenty-six (26) people's organizations (POs) in the municipalities of Candelaria and Sta. Cruz.

A. POs and NGOs of Municipality of Sta. Cruz

- **Farmer's Association**

Tubo-tubo Farmer's Association

- **Fisherfolks Association**

Bangan Malabago Fisherfolks Association

Bangan Gama Fisherfolks Association

SAMMBALS

Santa Cruz Public Market Fish Vendor Association (SACPUMAFIVA)

- **Multipurpose Cooperative**

Sea Lion Fisherfolks Producer's Cooperative

SMMAK-CBR

Guisguis Multipurpose Cooperative

- **Other relevant organization**

ZAMBREL

Rotary Club of Sta. Cruz

Sta. Cruz, Zambales Christian Association of Pastors

Kabayan Action Group

B. POs and NGOs of Municipality of Candelaria

- **Farmers Association**

Dalig-Hobol Irrigator's Association

Malimanga-Malabon-Sinabacan Farmer's Association

Uacon-Labnoy Farmer's Association

Barangay Sinabacan Farmer's Association

Candelaria Organic Farmer's Association

Paliyan Nin Malabon Irrigators Association

Catol Farmer's Association Inc.

Pamibian Farmer's Association Inc.

- **Fisher Folks Association**

SAMACA – Samahan ng Mangingisda ng Candelaria, Inc.

- **Other relevant organization**

CIL – Center of Independent Living

Jaime V. Ongpin Foundation, Inc.

Zambales Accredited Basketball Referees League

Team Candelari Riders, Inc.

Malatapi Community Livelihood Center, Inc.

2.4.8 Transportation

In Sta. Cruz, the land transportation facilities consist mainly of tricycles and jeepneys. Tricycles are mainly operating within the municipality, while jeepneys ply the route of Sta. Cruz – Candelaria – Masinloc – Palauig, Zambales and to Infanta – Dasol – Alaminos, Pangasinan. There are mini-buses and UVs plying the route of Sta. Cruz – Olongapo City and there are also other big bus companies, the Victory Liner and Five Star, whose transportation lines extend from Sta. Cruz to Dagupan City and Baguio City, to Tarlac City and Manila, and to Olongapo City and Caloocan City.

With regards to air transportation, there is at present only one privately owned airfield situated at Hermana Mayor Island which is in good condition and on sea transporation, a construction of seaport was already started in Barangay Bolitoc to be utilized as support facility to the proposed economic zones in Sta. Cruz.

2.4.9 Perception Survey Results

The perception survey was conducted in 9 project-impact barangays, of which 8 barangays belongs to the municipality of Candelaria and 1 barangay (Guinabon) belongs to the municipality of Sta. Cruz. There were 127 respondents, of which 94% are from Candelaria and 6% are from Sta. Cruz.

Table 111 - Distribution of Respondents per Barangay

Barangay	Number of Respondents	%
Guinabon	7	6%
Lauis	19	15%
Malabon	20	16%
Malimanga	12	9%
Pamibian	1	1%
Pinagrealan	20	16%
Sinabacan	20	16%
Taposo	17	13%
Uacon	11	9%
TOTAL	**127**	**100%**

2.4.9.1 Personal Information of Respondents

Most of the respondents are wives of the household head (46%). Only 31% are composed of household head. About 9% are parents of the household head and 7% are children of household head. Other repondents are sibling and relative that are living with the household head.

Table 112 -Household Position Distribution of Respondents

Description	Number of Respondent	%
Household head	39	31%
Wife of household head	59	46%
Child of household head	9	7%
Parents of household head	11	9%
Sibling of household head	1	1%
Other relative of household head	1	1%
Not applicable	7	6%
Total	**127**	100%

In terms of gender, 58% of the repondents are female, while 42% are female.

Table 113 - Gender Distribution of Respondents

Description	Number of Respondent	%
Male	53	42%
Female	74	58%
Total	**127**	100%

Majority of the repondents (80%) belong to the age bracket 30-69. Only 7% belong to age braket 15-29 and 9% to age braket 70 and above.

Table 114 - Age Distribution of Respondents

Description	Number of Respondent	%
15-19	5	4%
20-29	4	3%

Description	Number of Respondent	%
30-39	14	11%
40-49	32	25%
50-59	35	28%
60-69	21	17%
70 and above	12	9%
Not applicable	4	3%
Total	**127**	100%

Most of the respondents were born in the barangay (62%) where they are currently residing. About 18% were born in neighboring barangays and 13% were born outside the province of Zambales. Only 6% were born in the neigboring municipality of Candelaria and Sta. Cruz.

Table 115 - Birth Place Distribution of Respondents

Description	Number of Respondent	%
Barangay	79	62%
Neighboring barangay	23	18%
Neighboring municipality	8	6%
Other province	17	13%
Total	**127**	100%

Majority of the respondents (80%) are married, 10% are widow or widower, 8% are single and 2% are separated.

Table 116 - Civil Status Distribution of Respondents

Description	Number of Respondent	%
Single	10	8%
Married	101	80%
Widow/Widower	13	10%

Description	Number of Respondent	%
Separated	2	2%
Not applicable	1	1%
Total	**127**	100%

Majority of the respondents (92%) are affiliated to Roman Catholic. Only 3% are affiliated to Iglesia ni Cristo and 3% to other local religious groups such as Born Again Christian and Jehovah's Witness.

Table 117 - Religious Affiliation Distribution of Respondents

Description	Number of Respondent	%
Roman Catholic	117	92%
Iglesia Ni Cristo	4	3%
Others	4	3%
Not applicable	2	2%
Total	**127**	100%

About 79% of the respondents currently resides in their respective barangay. 10% have their residency in neighboring barangays. Others have their residency in neighboring province (9%) and municipality (1%).

Table 118 - Residence Distribution of Respondents

Description	Number of Respondent	%
Barangay	100	79%
Neighboring barangay	13	10%
Neighboring municipality	1	1%
Other province	12	9%
Not applicable	1	1%
Total	**127**	100%

About 36% of the respondents have lived in their barangay for more than 51 years already. Those who have been in their place of residency for 41-50 years represent 15%. Those that have 31-40 years and 21-30 years of residency represent 17% each respectively. Only 4% have stated that their residency is 1-10 years.

Table 119 - Period of Residency Distribution of Respondents

Description	Number of Respondent	%
1-10	5	4%
11-20	14	11%
21-30	21	17%
31-40	21	17%
41-50	19	15%
51 and above	46	36%
Not applicable	1	1%
Total	**127**	100%

Of the 127 respondents, 18% stated that their family is composed of six members. Respondents with four and five family members composed of 16% each respectively. 11% stated that their family is composed of seven members, 9% stated of nine and above family members, 9% with two members and 4% with eight members.

Table 120 -Family Member Distribution of Respondents

Description	Number of Respondent	%
Two	11	9%
Three	8	6%
Four	20	16%
Five	20	16%
Six	23	18%
Seven	14	11%

Description	Number of Respondent	%
Eight	5	4%
Nine and above	12	9%
Not applicable	14	11%
Total	**127**	100%

Majority of the repondents (81%) stated that only their family occupy their house. Only 6% occupy their house with some relatives.

Table 121 - House Occupancy Distribution of Respondents

Description	Number of Respondent	%
Yes	103	81%
No	2	2%
Others	5	4%
Not applicable	17	13%
Total	**127**	100%

2.4.9.2 Economic Information of Respondents

Most of the repondents stated that their primary source of income is being employed with government employee (42%). About 37% is farming and 11% is fishing. Some respondents also stated that they are also engaged in other income-generating activities to augment income, such as sari-sari store, transport services, farming and among others.

Table 122 - Primary Source of Income Distribution of Respondents

Description	Number of Respondent	%
No employment	9	7%
Fishing	14	11%
Government employee	53	42%

Description	Number of Respondent	%
Carpentry	1	1%
Transport service	3	2%
Private employee	3	2%
Construction	4	3%
Farming	34	27%
Self-employed	1	1%
Others	4	3%
Not applicable	1	1%
Total	**127**	100%

Most of the respondents stated that 24% of them has PhP 1,000.00 and less income. About 22% has income ranging from PhP 5,000.00 to PhP 10,000.00 and 13% has income ranging from PhP 3,000.00 to 3,999.00. Only 7% has income ranging from PhP 10,001.00 to PhP 15,000.00 and above.

Table 123 - Income Distribution of Respondents

Description	Number of Respondent	%
1,000 and less	31	24%
1,000 to 1,999	12	9%
2,000 to 2,999	8	6%
3,000 to 3,999	16	13%
4,000 to 4,999	12	9%
5,000 to 10,000	28	22%
10,001 to 15,000	6	5%
15,001 and above	2	2%
Not applicable	11	9%

Description	Number of Respondent	%
None	1	1%
Total	**127**	100%

In terms of employment, 27% of the respondents stated that about two of household member is employed. About 21% stated that only one household member is employed, while 10% responded that three members of the household is employed. About 7% of the respondent stated that employed household members is four to six.

Table 124 - Employment Distribution of Respondents

Description	Number of Respondent	%
One	27	21%
Two	34	27%
Three	13	10%
Four	4	3%
Five	2	2%
Six	2	2%
Not applicable	44	35%
None	1	1%
Total	**127**	100%

About 49% of respondents replied that the head of the family is the primary income earner. Mothers as primary income earner represents 7%. Son or daughter as primary income earner represents 12%. Respondents with numerous income earners represents 27%.

Table 125 - Main Income Earner Distribution of Respondents

Description	Number of Respondent	%
Father	62	49%

Description	Number of Respondent	%
Mother	9	7%
Son	10	8%
Daughter	5	4%
Male relative	1	1%
Female relative	1	1%
Numerous member of the family	34	27%
Not applicable	4	3%
None	1	1%
Total	**127**	100%

25% of respondents stated that household income ranges from PhP 5,000.00 to PhP 10,000. 14% has a household income ranging from PhP 10,001.00 to PhP 15,000.00. Those that have a household income of more than PhP 15,001 and above represents 9%.

About 69% of the respondents has a household income of PhP 10,000.00 and below.

Table 126 - Household Income Distribution of Respondents

Description	Number of Respondent	%
1,000 and less	9	7%
1,000 to 1,999	7	6%
2,000 to 2,999	8	6%
3,000 to 3,999	14	11%
4,000 to 4,999	17	13%
5,000 to 10,000	32	25%
10,001 to 15,000	18	14%
15,001 to 20,000	5	4%
20,001 and above	6	5%

Description	Number of Respondent	%
Not applicable	10	8%
None	1	1%
Total	**127**	100%

Most of the income are spent on food, electricity, transportation fare, education, medical needs and clothing.

2.4.9.3 Housing Information of Respondents

Most of the respondents have been already occupying their houses for years. About 75% have been occupying them for more than 10 years. Only 20% have occupied their houses 10 years and below.

Table 127 - House Occupancy Distribution of Respondents

Description	Number of Respondent	%
5 years and below	3	2%
5-10 years	22	17%
11-19 years	21	17%
20-29 years	26	20%
30-39 years	20	16%
40 years and above	28	22%
Not applicable	7	6%
Total	**127**	100%

Majority of the respondents (83%) owned the house they occupied. 13% stated that they do not own the houses but are not renting them. They were allowed by owners to stay without paying any rental.

Table 128 - House Ownership Distribution of Respondents

Description	Number of Respondent	%
Owner	105	83%
Not own and not renting	16	13%
Others	2	2%
Not applicable	4	3%
Total	**127**	100%

About 54% of the respondents replied that they owned the land where their houses are erected. 43% stated that they do not owned the land.

Table 129 - Land Ownership Distribution of Respondents

Description	Number of Respondent	%
Yes	68	54%
No	55	43%
Not applicable	4	3%
Total	**127**	100%

Majority of respondents (80%) used a water sealed type of toilet, while 6% used a non-water sealed toilet. Shared toilets represent 3%. Only 2% do not have toilet.

Table 130 - Toilet Distribution of Respondents

Description	Number of Respondent	%
Water sealed	102	80%
Non-water sealed	7	6%
Shared	4	3%
No toilet	2	2%
Not applicable	12	9%
Total	**127**	100%

About 65% of respondents sourced their water needs through deep wells that are often installed with jetmatic water pump. About 20% sourced their water through the municipal waterworks system. Only 2% derived their water needs from existing community water system.

Table 131 - Water Source Distribution of Respondents

Description	Number of Respondent	%
Water works system	26	20%
Deepwell	82	65%
Community faucet system	2	2%
Others	1	1%
Not applicable	16	13%
Total	**127**	100%

Majority of the respondents (90%) used LPG and firewood for their fuel needs. But most of them (56%) primary used LPG. Firewood used accounts 34%. Electricity (2%) and kerosene (1%) are rarely used for fuel.

Table 132 - Fuel Use Distribution of Respondents

Description	Number of Respondent	%
LPG	71	56%
Firewood	43	34%
Kerosene	1	1%
Electricity	2	2%
Others	1	1%
Not applicable	9	7%
Total	**127**	100%

Majority of the respondents (84%) used electricity for their energy needs. Firewood used for energy accounts 5%, while kerosene used accounts 2%.

Table 133 - Energy Use Distribution of Respondents

Description	Number of Respondent	%
Firewood	6	5%
Kerosene	2	2%
Electricity	107	84%
Others	2	2%
Not applicable	10	8%
Total	**127**	100%

2.4.9.4 Education, Health, Communication and Entertainment Information of Respondents

The educational attainment of respondents are generally distributed in different levels. About 31% are high school graduate, 18% are college level, 13% are vocational, 11% are high school level, 10% are college graduate, 6% are elementary graduate and 5% are elementary level.

Table 134 -Educational Attainment Distribution of Respondents

Description	Number of Respondent	%
Elementary Level	6	5%
Elementary Graduate	8	6%
High School Level	14	11%
High School Graduate	39	31%
College Level	23	18%
College Graduate	13	10%
Vocational Course	17	13%
Not applicable	7	6%
Total	**127**	100%

Majority of the respondents stated that there are numerous members of their households that they are currently supporting for they education. Most of these members of their households are in high school (rank 1), elementary (rank 2) and college levels.

Educational support are mostly given by parents (60%). Only 6% are supported by relatives. About 6% are supported through the 4Ps program of the government. About 9% of the respondents shared that the educational support to their children are jointly supported by them and either relatives, son/daughter, barangay or scholarship offered by some companies operating in the area.

Table 135 - Educational Support Distribution of Respondents

Description	Number of Respondent	%
Parents	76	60%
Relative	7	6%
4Ps	8	6%
Not applicable	36	28%
Total	**127**	100%

Respondents also shared that there are cases of students discontinuing their education because of some reasons. Based on the result of the survey, about 17% of the students have experienced this.

Table 136 - Education Discontinuation Distribution of Respondents

Description	Number of Respondent	%
One	17	13%
Two	3	2%
Three	1	1%
Four	1	1%
None	41	32%
Not applicable	64	50%
Total	**127**	100%

About 17% of the respondents stated that the limited financial resource is the main reason for the discontinuation of education of their children. About 5% cited the need for their children to work to to be able to augment for the financial needs of the family. Only 2% cited health reasons. Other respondent stated that their children drop out because of their lack of interest to finish their education.

Table 137 - Education Discontinuation Reason Distribution of Respondents

Description	Number of Respondent	%
Limited financial resources	21	17%
The need to work	6	5%
Health reason	2	2%
Others	2	2%
None	4	3%
Not applicable	92	72%
Total	**127**	100%

Majority of the respondents shared that they experienced one to three illness during the previous year. About 26% experienced two illness, while 23% experienced one illness. Respondents that experienced three illness represents 11%. The common illness experienced are colds, diarrehea, hypertension, flu, UTI, asthma, diabetes and skin allergies.

Table 138 - Illness Experience Distribution of Respondents

Description	Number of Respondent	%
One	29	23%
Two	33	26%
Three	14	11%
Four	3	2%
Five	3	2%
Six	2	2%
Seven or more	1	1%
None	20	16%
Not applicable	22	17%
Total	**127**	100%

About 51% of the respondents avail the services at their public hospital for their health and medical needs, while 16% avail the services at their barangay health center. 10% avail the services of a private doctor.

Table 139 - Health Services Distribution of Respondents

Description	Number of Respondent	%
At home	14	11%

Description	Number of Respondent	%
Barangay health center	20	16%
Private doctor	13	10%
Public hospital	65	51%
Not applicable	15	12%
Total	**127**	100%

In case of occurrence of death cases for the past year, 76% of the respondents have not experienced such case. Only 13% stated that they experienced it.

Table 140 - Household Death Cases Distribution of Respondents

Description	Number of Respondent	%
Yes	16	13%
No	97	76%
Not applicable	14	11%
Total	**127**	100%

About 58% of the repondents stated that they are burning their solid wastes, while 20% stated that they are disposing it through open shallow pit. 11% brings their wastes to dumpsite. Only 5% stated that wastes are collected.

Table 141 - Solid Wastes Disposal Distribution of Respondents

Description	Number of Respondent	%
Bring to dumpsite	14	11%
Open shallow pit	25	20%
Collected by barangay or LGU	6	5%
Burning	74	58%
Others	4	3%
Not applicable	4	3%
Total	**127**	100%

61% of the respondents stated that they sourced their information from various communication medium such as TV, radio, cellphone, barangay, internet and newspaper. About 35% of the repondents stated that they sourced information directly from TV.

Table 142 - Communication Source Distribution of Respondents

Description	Number of Respondent	%
TV	44	35%
Various communication medium	78	61%
Not applicable	5	4%
Total	**127**	100%

TV is the primary medium of entertainment by 72% of respondents. About 20% used different entertainment medium.

Table 143 - Entertainment Source Distribution of Respondents

Description	Number of Respondent	%
TV	92	72%
Various entertainment medium	25	20%
Not applicable	10	8%
Total	**127**	100%

2.4.9.5 Community Information of Respondents

About 76% of the respondents stated that they are members of local community organizations in their area. while 13% has no organizational membership at all.

Table 144 - Organization Membership Distribution of Respondents

Description	Number of Respondent	%
Yes	97	76%
No	16	13%
Not applicable	14	11%
Total	**127**	100%

Some existing local organizations are senior citizen, farmers, women, fisherfolks, TODA, KAPILI, and cooperative. 24% belongs to barangay volunteer group, 15% belongs to senior citizen group, 11% belongs to farmers' group and 11% to womens' group. The 19% belongs to different other organizations such as fisherfolks, TODA, KAPILI and cooperative.

Table 145 - Organization Distribution of Respondents

Description	Number of Respondent	%
Senior citizen	19	15%
Farmer's organization	14	11%
Women organization	14	11%
Barangay volunteer	30	24%
Others	24	19%
Not applicable	26	20%
Total	**127**	100%

Majority of the respondents cited that most of the problems in the community are unemployment, lack of acces to clean potable water, poverty, malnutrition, limited water supply for irrigation, limited resources for learning, limited access to scholarship and educational assistance, limited number of teachers, limited medical equipment in barangay health centers, lack of livelihood assistance, limited access to capital for business, limited recreational facilities, limited assistance for farmers, limited community capacity building and proper wastes disposal.

Some of the solutions to community problems identified by the respondents are employment, livelihood programs, capacity building, scholarship and educational assistance, access to clean water, health programs, solid wstes management program, government assistance, corporate social responsibility program of private companies and values formation.

2.4.9.6 Perception on WestChinaMin Project

58% of the repondents are aware about the project, while 36% are not.

Table 146 - Project Awareness Distribution of Respondents

Description	Number of Respondent	%
Yes	74	58%
No	46	36%
Not applicable	7	6%
Total	**127**	100%

The respondents' awareness about the project came from government/barangay official with 14%, barangay meetings/consultations got 13% and officials/employees of WestChinaMin got

12%. Only 1% of the respondents got the information either from TV, radio and local newspaper. About 2% said that they did not hear of the project.

Table 147 - Project Information Source Distribution of Respondents

Description	Number of Respondent	%
Government/Barangay Officials	18	14%
Officials/employees of WestChinaMin	15	12%
Radio/TV/local newspaper	1	1%
Barangay meetings/consultations	16	13%
None	2	2%
Not applicable	51	40%
Others	24	19%
Total	**127**	100%

The respondents perceived that there are positive and negative effects of the project. The perceived positive effects are employment opportunities, additional income and taxes to the local government and community development programs. The perceived negative effects are dust, noise, generation of wastes and improper wastes disposal, road traffic, health and environmental hazards and peace and order.

Majority of the respondents expressed that the negative effects of the project can be resolved in different ways such as conduct of regular dialogues with the community and local government, implementation of environmental programs (planting of trees, environmental impact measures), safety and health programs, information dissemination, construction of private hauling road and implementation of emergency preparedness program.

About 24% of respondents expressed their acceptance to the the project, while 13% expressed their apprehension to the project.

Table 148 - Project Response Distribution of Respondents

Description	Number of Respondent	%
Yes	30	24%
No	17	13%
Undecided	64	50%
Not applicable	16	13%
Total	**127**	100%

2.4.10 Focus Group Discussion (FGD) Results

Focus group discussions (FGDs) were undertaken from May 29-June 1, 2018 in 9 project impact barangays of the project. The main objective was to gather issues and concerns of the community with regard to the project and understand their perception and insights. The FGDs were attended by various members of the community such as barangay officials, women, farmers, fisherfolks, senior citizens, barangay health workers and among others.

The highlights of the discussions are categorized as perceived benefits, negative impacts and sulutions summarized in *Table 149*.

Table 149 - Focus Group Discussion Highlights

Perceived Benefits	Perceived Negative Impacts	Perceived Solutions
Employment	Employment opportunities are generally concentrated to communities located near mining areas.	Equal opportunities for employment
	Loss of job due to suspension of mining operation	Alternative livelihood
Availability of funds for community development programs covering various projects related to education, livelihood, health, socio-cultural, infrastructure	Implementation of SDMP is concentrated only to identified host and neighboring communities.	Extent the benefits of SDMP to other barangays not identified as host and neighboring barangays
Increase IRA of barangay	Slow release of excise tax share of barangay from the national government	Immediate release of excise tax share of barangay
	Siltation of rivers	Ensure responsible mining and implement the necessary environmental mitigating measures.
	Pollution of rivers from generated wasteswater from plant	
	Siltation of farmlands	
	Comtamination of coastal areas	

Perceived Benefits	Perceived Negative Impacts	Perceived Solutions
	Air pollution due to dust generation	
	Solid wastes disposal	
	Road safety and traffic along national road	Construction of alternative hauling road
	Damage to roads	
	Flooding/flashfloods in the community	Construction of flood control measures
	Loss of trees in the mountain due to mining	Planting of trees
	Negative perception on mining due to lack of information dissemination	Intensify information awareness campaign

During the discussion, some attendees have expressed support to the project, while some have expressed reservation. Furthermore, not one expressed any intense apprehension against the project.

3.0 IMPACT MANAGEMENT PLAN

3.1 Performance of the Current IMP Implementation

Although the existing project is non-operational, the company ensures that the management plan formulated on the current ECC is strictly implemented. The table below summarizes the IMP compliance of the company.

ECC/EMP Condition / Requirement Categorization	**Relevant ECC Condition/s** (if any)		**Status of Compliance** (if complying)	**REMARKS**
	#/s	**Requirement Description**		
Impact Mitigation Plan or Construction / Contractor's Environmental Program		• Observance of appropriate vegetative practices, sound soil management and proper waste management • Formulate a reforestation and carbon sink program to mitigate GHG • National Greening Program in coordination with DENR-PENRO of Zambales and EMB (CO & RO3) • Establishment of 10 meter buffer zones along the periphery of the project site • Submit a storm/run-off management plan and Water Pollution Control Facilities • The mining operations shall conform with the provisions of RA 8749, RA 9275, RA 9003 and RA 6969 and their respective IRR	✓	• The company is implementing an Environmental Program within the company premises by planting trees and constant re-greening through landscaping activities by maintaining a nursery; • Strict implementation of Waste Segregation before disposing to the EMB accredited HazWaste Transporter and Municipal Garbage Collector • Progressive rehabilitation of mined-out area using overburden and endemic plants;

ECC/EMP Condition / Requirement Categorization	Relevant ECC Condition/s (if any)		Status of Compliance (if complying)	REMARKS
	#/s	Requirement Description		
		• That the proponent shall ensure that its contractor and sub-contractors shall strictly comply with the relevant ECC conditions		• Regular desludging of settling ponds • Will set-up temporary fence like Kakawate Trees that serves as markers to the Buffer Zone • Hyuma Mining Company has an existing Operating Agreement with Westchinamin

3.1.1 Impact Management Plan

The Impact Management Plan (IMP) is formulated to minimize the potential adverse impacts while enhancing the beneficial effects of implementation of the project. This IMP, as summarized in *Table 150*, shall serve as the implementing guideline to ensure that environmental requirements are met during the project implementation. Programs indicated can be updated during the monitoring of the perceived project impacts.

Further, since the proposed project will deviate from the existing ECC coverage the management/mitigating measures stipulated below will encompass the existing measures with additional procedures.

Table 150 - Impact Management Plan

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
CONSTRUCTION PHASE						
Construction of Plant Complex	Pedology	– Possible increase in surface erosion and down slope sedimentation brought about by mining area development activities – · Earthworks, mine facility and Processing plant construction activities, and movement of heavy equipment will highly disturb the soil surface (i.e. compaction and smearing during the wet season and, dust generation during the dry season) and induce the natural erosion susceptibility of the ultramafic soil –	– · Progressive ground clearing/preparation will be employed to minimize the area disturbed at any one time – · Immediate progressive soil rehabilitation will be conducted in disturbed or cleared areas that will not be used for further development over the course of the project. – · Appropriate erosion/sedimentation controls will be installed to mitigate surface erosion and the consequent down slope or downstream sedimentation. These will include: 1). Installation of rainwater and runoff collecting systems at the toe of work areas and inclusion of a systematically designed diversion canals to intercept runoff water before reaching the runoff collecting systems;	Proponent	Part of the Project Cost	ECC, EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
	Soil Quality	– ·Top soil removal will be unavoidable to make way for the development of mine infrastructures, ancillary facilities and new access and, service roads – Improper disposal of domestic wastes may contaminate the soil – Soil Contamination due to accidental fuel and lubricant spills from vehicles and equipment may occur	2). "Vengineering" (i.e. planting of known vegetation with high rainfall intercepting capacity and high transpiration rate characteristics to serve as re-evaporator/biological pumps). – Appropriate top soil removed during the clearing, re-grading and ground preparation activities before/during construction will be conserved and stockpiled in a delegated topsoil stockpile area for use in the rehabilitation activities or backfilling of service roads. – Ground preparation and grubbing will be conducted progressively to minimize the total area of soil cover at any one time. – A detailed topsoil management plan (TMP) will be formulated and implemented to address topsoil stripping methods and depths, stock filing, and archiving of topsoil			

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			inventory for the project progressive rehabilitation activities. – All domestic wastes will be sold to recyclers. Residual waste will be disposed to a designated sanitary land fill. – All waste/used oils, lubricants, rugs and chemicals will be sold to recyclers. Residual waste will be disposed to a designated sanitary land fill. – Installation of Auto Shutoff Valves in the fuel/oil and lubricant refilling stations. – Contaminated soils will be removed and disposed off site. – Provision of Refuse storage facility with oil and water separator to contain any accidental spill.			

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
	Terrestrial flora	– Loss of vegetation due to site clearing – Possible fragmentation of the species biogeographic range – Loss of endemic and vulnerable species – Possible loss of etno-botanically important species – Soil alteration may cause anaerobic condition that may hinder plant growth in some areas – Charcoal-making may be more rampant if areas became more cleared – Fragmentation and loss of wildlife species' habitat	– Prevention of areas with thick vegetative cover – Progressive rehabilitation of the disturbed site – Properly planned clearance of vegetation to avoid unnecessary cutting of trees – Conservation of determined endangered and vulnerable floral species – Use of indigenous species in rehabilitation mixed with known reforestation species such as Acacia mangium and A. auriculiformis to ensure local species biodiversity while doing reforestation – Establishment of buffer zones along creeks – Include flora and fauna protection programs in the IEC component of the SDMP – Routine monitoring of terrestrial flora and fauna	MEPEO; MMT; Proponent		Included in EPEP, ECC condition

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
	Terrestrial fauna	– Disturbance, displacement and/or removal of wildlife population especially threatened species. – Long term changes in the community structure, distribution and abundance of wildlife species – Physiological and reproductive stress for some species – Increased threat from illegal hunting/poaching	– Annual assessment and monitoring activities for wildlife such as diversity and population assessments – Prioritize population studies and/or conservation programs/projects for threatened species (listed in IUCN, CITES and DENR DAO) – Designation of buffer zones that will serve as refuge for displaced species – Progressive rehabilitation of mined-out areas that will serve as corridors for the wildlife species – Construction of temporary shelters/cages for accidentally caught and turned over species – Increased security and apprehension of illegal/suspected hunters/poachers			
Clearing and site preparation	Water Quality	– Generation of contaminated runoff coming from the construction area	– Enclose the construction area; – Install temporary drainage canals during construction;	Proponent / Contractor	Part of construction cost	Work Program

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
(Admin Complex)		– Accidental oil spill	– Good housekeeping practices; – Develop and implement an oil spill contingency plan;			
Clearing and overburden removal (Mining)		– Generation of silted runoff coming from the mine site	– Install temporary drainage canals; – Designate spoil disposal areas located away from gullies – Maintain buffer zones along river banks	Proponent / Contractor	Part of construction cost	Work Program
Site Clearing Mine site development Construction of access roads	Surface and coastal water Quality Marine pollution from organic wastes and effluents	– soil erosion, siltation in surface water bodies by eroded soils and/or dumping or accidental large volume of spilled materials during handling – deterioration of surface water quality resulting from increased siltation of surface runoff	– Implement erosion control structures, drainage system, and silt/ flood detention ponds; – minimize ground clearing and other earth works near river systems; – immediate re-greening of waterways and reinforce vegetative cover of riverbanks with rows of deep-rooted vegetation	Proponent and coastal habitat monitoring team	Part of construction cost	EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
		– marine pollution due to discharge of spilled oil and/or other hazardous materials from vehicles and equipment; – further deterioration of coastal water quality due to increased siltation and sediment fluxes – suffocation of coral colonies, seagrass beds, alteration of macro-invertebrate habitats – reduction of plankton communities affecting primary production – pollution of coastal waters through accumulated wastes	– regularly desilt settling ponds and clogged waterways; – provision of equipment repair facilities away from waterways with oil and grease separator and recovery system – Regularly conduct monitoring of river and coastal water quality with alert indicators on excessive silt plumes from point sources in the mine site. – Conduct annual marine ecology monitoring to discern changes in condition of reefs, seagrass, plankton density and benthos diversity due to anthropogenic disturbances. – On-site collection and segregation of wastes – Install efficient three-chambered septic tanks in all mine site facilities and implement an efficient wastewater collection and treatment on site			

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– Regularly conduct monitoring of river and coastal water quality with alert indicators on excessive silt plumes from point sources in the mine site. – Conduct annual marine ecology monitoring to discern changes in condition of reefs, seagrass, plankton density and benthos diversity and fisheries species richness and abundance due to anthropogenic disturbances. – Support the two marine protected areas in Candelaria through local capacity building and annual MPA monitoring – On-site collection and segregation of wastes –			
	Air quality/ Ambient Noise	– Noise disturbance – Fugitive dust generation – Vehicle/equipment emissions	– Strictly implement covering of hauling trucks and water spraying; – Preventive maintenance of vehicles and equipment	Proponent		Included in EPEP, ECC condition

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– Enclosure of equipment emitting high level of noise (when applicable) – Imposition of speed limits – Provision of dust and noise PPEs to employees			
	Economic	– Employment of skilled and non-skilled workers – Diversification of local industries – Not everybody will be employed	– Implementation of a hiring policy giving preferential to locally-qualified individuals of project-impact barangay – Development of a hiring policy that is gender sensitive and giving equal opportunities to both sexes – Implementation of the Social Development and Management Program (SDMP) to provide opportunities for those who will not be hired – Incorporate a scheme and protocol of hiring in the agreement; coordinate the scheme and protocol with the barangay and MLGU – IEC on nature and qualification of jobs the proponent requires; Consultation on job requirements and qualification	– Proponent CRO – Barangay MLGU		Included in EPEP, SDMP, ECC condition

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– Skills training to upgrade local skills of residents that can be hired			
	Health and Safety	– Unauthorized entry of outsiders and establishments which might cause problems in peace and order – Entry of migrant workers with families, which might cause health problems due to diseases, overuse of public utilities /services, competition of resources, social conflicts, peace and order, increase in pollution due to solid and liquid wastes. – Increase in traffic flow causing air (dust) and noise pollution; traffic/road safety – Environmental degradation	– Implementation of a health and safety program and EPEP – Establish a grievance mechanism to manage issues and concerns arising from the project – Implementation of an IEC program that will explain the nature and operation of the project – Implement an integrated solid waste management plan in coordination with the barangay and MLGU – Coordination with the Barangay LGU to ensure authorized establishments and control of unauthorized entry of outsiders – Buffer zones should be established around the perimeter of the mines – Proponent to provide Health clinic – Health certificate for workers prior to hiring into the project	– MHO – Barangay LGU – Barangay Tanod – Barangay Health Workers – ProponetCRO		

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
		– **Impact of climate change** such as La Niña and El Niño phenomenon and possible consequential disasters	– Partner with the LGU the implementation of the Social Development and Management Program – Maintenance of hauling trucks to avoid smoke belching; Sprinkling of roads during dry seasons			
	Social	– Entry of migrant workers with families, which might cause problems of congestion, peace and order and security, breaches. – Influx of migrant workers may put pressures on public utilities and services – Social conflicts leading to disruption of community cohesion – Loss of income due to suspension of the mine	– Implementation of a hiring policy giving preferential to locally-qualified individuals of project-impact barangay – Regulation by the barangay and MLGU to manage entry of migrant workers and their families – Coordination with the Barangay LGU to ensure authorized establishments and control of unauthorized entry of outsiders – Implementation of community-related regulation by the barangay and MLGU to mitigate social conflicts, control leisure related activities, such as drinking			

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– Implementation of SDMP – Establish a grievance mechanism to manage issues and concerns arising from the project – Implementation of a communication program that promotes public involvement and dialogue/consultation			
OPERATION PHASE						
Processing	Soil Quality	– Soil Contamination due to accidental chemical spills from the assay laboratory	– · Proper handling of chemicals used will be implemented during the mine life. Training of all personnel involved in the transport of ore and non-ore materials will be required. This will ensure safe and effective material transport operations and reduce contamination risks. – ·An emergency containment and clean-up program will be developed to handle any occurrence of soil contamination.	Proponent	Part of the Project Cost	ECC, EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
		– Improper disposal of domestic wastes may contaminate the soil at the immediate and adjacent areas of disposal. – – Soil Contamination due to: – 1. Accidental fuel and lubricant spills from vehicles and equipment may occur – – – – – 2. Processing Plant raw materials/Slag Stockpile areas	– All domestic wastes will be disposed of in accordance with the construction and operation waste management plan that will be developed – – – Waste oils, lubricants and chemicals will be placed in designated storage tanks. Disposal of these waste will be in accordance of the project's waste management plan for non-mine wastes that will be generated prior to construction. This will include procedures for Hydrocarbon collection. – – Raw ore materials/and slag stockpile areas of the processing plant will be provided with drainage canals so as to contain runoff carrying soil/silt and other materials and contained in silt and settling ponds before discharged to receiving bodies of water.	Proponent	Part of the Project Cost	ECC, EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			Stockpiles will be provided with tarpaulin to serve as protective cover from dust generation/runoff. –			
	Terrestrial flora	– Loss of vegetation due to site clearing – Possible fragmentation of the species biogeographic range – Loss of endemic and vulnerable species – Possible loss of etno-botanically important species – Soil alteration may cause anaerobic condition that may hinder plant growth in some areas	– Prevention of areas with thick vegetative cover – Progressive rehabilitation of the disturbed site – Properly planned clearance of vegetation to avoid unnecessary cutting of trees – Conservation of determined endangered and vulnerable floral species – Use of indigenous species in rehabilitation mixed with known reforestation species such as Acacia mangium and A. auriculiformis to ensure local species biodiversity while doing reforestation – Establishment of buffer zones along creeks	Proponent	Part of operating expenses	EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
	Terrestrial fauna	– Fragmentation of wildlife species' habitat – Disturbance, displacement and/or removal of wildlife species – Long term changes in the biology of wildlife species' (population and community dynamics, behavior and physiology) – Possible occurrence of poaching/hunting	– Include flora and fauna protection programs in the IEC component of the SDMP – Routine monitoring of terrestrial flora and fauna – Progressive rehabilitation to create corridors for wildlife species – Rehabilitation of mined-out areas prior to mining other parcels – Temporary shelters/cages for accidentally caught species – Increased security and apprehension of illegal/suspected hunters/poachers –			
Activities at the Motorpool/ shop	Water Quality	Accidental oil spill	– Develop and implement an oil spill contingency plan; – Good housekeeping practices; – Continuous training of personnel as part of emergency response plan; – Provision of adequately-sized secondary containment for oil/fuel storage areas	Proponent	Part of operating expenses	EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
Ore Mining Stockpiling of loose materials (overburden, ore)		Generation of silted runoff coming from opened-up areas such as mine areas and roads	– Provision of drainage canals with lining (e.g. rock lining) along haul roads; – Install silt traps along the canals; – Construction of a drainage system within the mine site; Divert clean runoff away from the work areas; Collect silted runoff from the work areas to be conveyed to sedimentation ponds; – Construction of a series of sedimentation ponds connected to the drainage system within the mine site; – Regular maintenance of sedimentation ponds especially during the wet season; – Management of stockpiles – should be located away from flood-prone areas or gullies – Implementation of progressive rehabilitation;	Proponent	Part of operating expenses	EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– Implementation of vegetative and engineering measures to stabilize cut slopes along roads, and streambank stabilization; – Maintain buffer zones away from the natural waterways			
Processing Stockpiling of ore	Water Quality	Discharge of effluent that may cause surface and groundwater pollution	– Provision of a wastewater treatment facility – Construction of a drainage system within the Admin Complex – Provision of silt traps, sedimentation ponds and oil & water separators	Proponent	Part of operating expenses	EPEP
Regular activities within the Admin Complex	Land Water	Generation of wastes (sewage, solid waste, hazardous wastes etc.) Water pollution, land contamination	– Monitoring of waste generated by the project, use appropriate storage containers especially for hazardous wastes to prevent any leakage or spill – Disposal and treatment of hazardous waste via DENR accredited transporter/treater. – Implement waste segregation, provide adequate trash bins at the site	Proponent	Part of operating expenses	EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
Use of water for domestic (washing) and industrial use (processing, road watering, nursery, etc.)	Water	Water Use Competition	– Implementation of water conservation measures (recycling of process water if feasible); – Apply for NWRB water permits for all activities that require water extraction from groundwater (deep wells) and/or surface water (rivers); – Monitor extraction rate through installation of flow meters to ensure that the rate of extraction is within the allowable limit set by the NWRB	Proponent	Part of operating expenses	EPEP
Surface mine operation and nickel extraction including transport of ores	Coastal water quality deterioration	– Deterioration of coastal quality, sediment blanketing in reef and seagrss areas, reduced plankton and benthos community, disruption of fish habitats, feeding, reproduction and larval success; – marine pollution due to discharge of spilled oil and/or other hazardous	– maintain efficiency of erosion control structures, drainage system, and silt/ flood detention ponds; – Installation of silt curtains in points where sediments can escape and be carried downstream into coastal waters; – Regular desilting of catchment basins / settling ponds – Recycling of surface water run-off collected in the silt basin for dust	Proponent and coastal habitat monitoring team	Part of operating expenses	EPEP

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
		materials from vehicles and equipment; – pollution of coastal waters through accumulated wastes carried downstream – reduced fisheries productivity as a result of migration of fish out of disturbed coastal region	control and watering of vegetative rehabilitation measures. – Implement an oil and grease recovery system; – On-site collection and segregation of wastes – Adopt best practices on seagrass enhancement; – Support fisheries alternative livelihood projects and mangrove reforestation with aquasilviculture of mangrove crabs and finfish mariculture in Uacon lake; – Explore feasibility of re-stocking appropriate species of hatchery-produced finfish and shellfish in special management areas inside Uacon lake.			
	Air	– Local increase in TSP and noise levels – Air pollution from gas emissions of heavy equipment.	– Proper and regular maintenance of equipment – Water spraying; mining activities to be confined during daytime as much as possible	Proponent	Included in the EPEP budget	

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– IEC on proper scheduling of hauler trucks to avoid busy and late hours			
	Economic	– Local government generation of revenues from taxes, permits and LGU share in the mining and processing of Nickel – Royalties and taxes paid locally and shared by municipal and barangay	– Benefit from development programs through **SDMP** equivalent to 1.5% of operating cost – Total taxes paid to the national government will exceed Excise Tax: 60% goes to national government; 40%, to the local government -- – Real Property Tax to province and municipalities – Development of small and medium enterprises like transport, construction and utility services	– LGU Proponent CRO		
		– Generation of employment	– IEC on nature of jobs the proponents require and qualification. – Multiplier Effect: – Consultation on job requirements and qualification – Local hiring priority for qualified Barangay residents	– Barangay LGU – Proponent CRO – TESDA		

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– Skills training to upgrade local skills of residents that can be hired by the project			
		– Cause problems of congestion, peace and order, and security breaches	– Generation of livelihood opportunities and other services near the affected communities – Coordination with the Barangay LGU to ensure authorized establishments and control of unauthorized entry of outsiders as well as the management of waste. – Buffer zones should be established around the perimeter of the MPSA	– Barangay LGU & Tanods – Proponent CRO IEC – Security Force		
	Health and safety	– Entry of migrant workers with families which might cause health problems due to diseases, overuse of public utilities /services, competition of resources, social conflicts, peace and order, increase in pollution due to solid and liquid wastes.	– Management of entry of migrant workers. – Increase and train Barangay tanods to be deployed in areas where migrant workers reside. – Proponent provide Health clinic with a Doctor, Nurse and Health workers – Health certificate for workers prior to hiring into the project	– Barangay LGU – Barangay Tanod – MHO – Proponent CRO		

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
			– Partner with the LGU the implementation of the Social Development Program			
ABANDONMENT PHASE						
Clearing / removal of support facilities	Land / Water / People	Accidental spill of toxic and hazardous wastes	– Proper implementation of the approved rehabilitation and abandonment plan – Use of DENR-accredited haulers/TSD companies for hazardous wastes	Proponent		FMRDF
– Rehabilitation of mined-out areas Dismantling of structures		Generation of Solid Waste	– Recyclable materials will be sold to recyclers. Residual wastes will be hand over to the municipal garbage collectors. Hazardous waste will be transported to accredited disposal Companies.	LGU, MRFC/MMT, EHS		
	Further deterioration of coastal water quality	– Slope erosion of rehabilitated areas may be carried downstream by rainwater run-off; – Solid waste generated from dismantling of structures in the site can	– Proper and regular maintenance of vegetative slope protection and contour canals and drainage system of mined-out areas to ensure that terraces and benches have nil erosion potential and drainage facilities are			

Project phase/ Environmental aspect	Environmental component likely to be affected	Potential impact	Options for prevention, mitigation or enhancement	Responsible entity	Cost	Guarantee / Financial agreement
		end up in waterways and carried downstream,	functional during the decommissioning phase – Conduct regular monitoring of sediment plumes in river systems and in Uacon lake; – Conduct marine ecology assessment;			

4.0 ENVIRONMENTAL RISK ASSESSMENT (ERA) AND EMERGENCY RESPONSE POLICY AND GUIDELINES

4.1 Objective

The objective of this environmental risk assessment (ERA) is to analyze the hazards and characterize the risks and associated with the proposed Ferro-Nickel Processing Plant and Nickel Mining Expansion Project for WestChinaMin. It also aims to come up with recommendations on risk mitigation and management based on the results of the risk assessment.

4.2 Scope and Limitations

Risk characterization focused on safety as well as physical hazards. Safety hazards refer to fire, explosion and release of toxic substances. Physical hazards, on the other hand, refer to possible failure of structures that could pose threat to life, property and/or the environment. Potential accident consequences were described in terms of loss of human lives or injuries and damage to the environment. The guideline in *Annex 2-7e, Revised Procedural Manual for DAO 2003-30* indicated that the required ERA is qualitative and descriptive in nature. Assessment of hazardous substances focused on coal, a combustible raw ingredient in the processing of nickel ore into ferronickel alloy. Occupational safety risks were also addressed.

Risk screening using the guidelines in *Annex 2-7e, Procedural Manual for DAO 2003-30* showed that the Total Indicative Sum (TIS) of hazardous substances, with respect to their threshold inventories, did not exceed unity (1). As such, conduct of this ERA was mainly qualitative and limited to worst-case accident scenario analysis for the ferronickel alloy processing component.

4.3 ERA Conceptual Framework

4.3.1 The Environmental Risk Assessment Process

The Procedural Manual for DAO 2003-30 defines environmental risk assessment as "the use of universally accepted and scientific methods to assess the risks associated with a project. It focuses on determining the probability of occurrence of accidents and their magnitude. Risk is defined as a measure of potential human injury/ death, economic loss, or environmental damage in terms of the probability of the loss, injury/ death or damage occurring and the magnitude of the loss, injury/ death or damage if it occurs. Risk involves two measurable parameters: consequence and probability. In the context of this study, risk refers to qualitative or quantitative measure of hazards associated with the proposed Ferro-Nickel Processing Plant and Nickel Mining Expansion Project in Zambales.

4.3.2 The ERA Framework

The general framework of this ERA is illustrated in *Figure 127*.

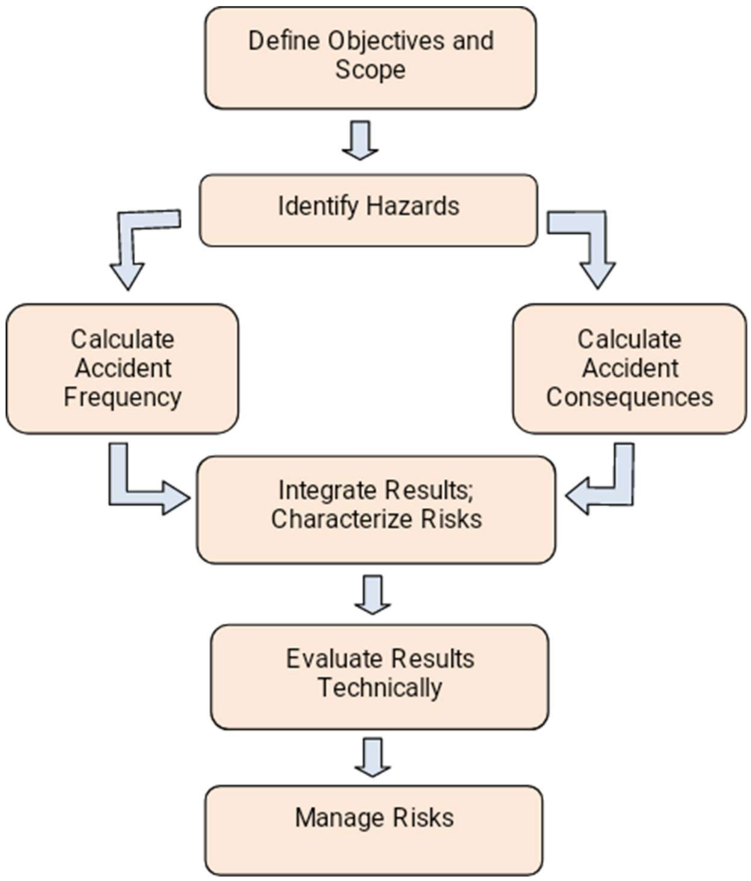


Figure 127 - The Risk Assessment Procedure

4.3.3 Hazard Identification

The various hazardous processes, activities and substances associated with the proposed Project were identified at this stage. Hazardous activities and processes with potential to cause onsite and offsite injuries and fatalities to people were determined. The potential of substances to be explosive, flammable, and/or toxic was analyzed. The most likely initiating events and causes of failures leading to the occurrence of hazardous incidents were analyzed vis-à-vis the operation of the proposed expanded nickel mining and ferronickel alloy processing project.

4.3.4 Consequence Analysis

Consequence analysis involved the estimation of unwanted consequences, effects, impacts or outcomes of projected major hazard incidents involving specific activities and substances in the facility. Major hazard incidents mean accidents involving hazardous activities or substances that have an impact in terms of death, injury or evacuation of people, damage to property or lasting harm to the environment.

The consequence analysis focused on accident scenarios that involve the release of flammable, explosive and/or toxic substances. Estimated was the consequence of worst-case accident scenario involving the storage and utilization of pulverized coal. Modeled was the worst-case accident scenario for potential coal dust explosion.

4.3.5 Frequency Analysis

Frequency analysis is not necessary in worst-case accident scenario analysis, as the objective in such study is primarily to define the worst-case hazard zones.

4.3.5.1 Risk Characterization

Due to the qualitative nature of this ERA, risk characterization focused on description of the risks associated with the various hazards inherent to activities, substances and conditions at the mining site and the processing plant. This included natural hazards arising from extreme climate events such as tropical cyclones, flooding, landslides and storm surges; as well as from earthquakes. For the fire/explosion hazards of coal, risks were characterized using the ERA Guidelines in DAO 2003-30.

4.4 Hazard Identification

4.4.1 Nickel Laterite Mining

Hazards associated with the nickel laterite mining component include mass movement of soil and rocks, release of contaminated sediments from settling ponds, occupational safety hazards, toxicity from laboratory assay chemicals, and fire due to storage/utilization of flammable substances, particularly liquid fuel. Exposure to heavy metals and minerals from mining activities and wastes may likewise exert toxicity impacts to people, animals and plants in the affected area.

Fire hazard is chiefly attributable to storage of diesel and lube oil. Occupational safety hazards may occur at the various project phases and processes from ground clearing to ore feeding and shipment. Outcomes from occupational safety hazards include deaths and injuries resulting from ground/structure failure, fall from heights, being struck or crushed by equipment parts or falling rocks/debris, vehicular/equipment accidents, and others. Mass movement of soil/rocks/sediments may result from breach of containing walls of impoundment and berms, overburden storage facilities and settling ponds. It may also arise as a direct result of ore extraction activities. Such incidents may be triggered by natural events such as inclement weather conditions (heavy and sustained rains, typhoons, storm surges, etc.), earthquakes and subsidence; faulty engineering design; inadequate maintenance of structures; and sabotage. Water contamination could result from the release of heavy metal-laden sediments and run offs, mining overburden and wastes to water bodies, particularly the streams and coastline. The water bodies could also become heavily silted with sediments.

4.4.2 Ferronickel Alloy Processing

Hazards associated with processing of nickel ores into ferronickel alloy pellets are the following:

- Flammability and explosive potential of coal, a raw material in ferronickel alloy processing;
- Fugitive toxic fumes and gases from the smelting of nickel ores, which may include carbon monoxide (CO), nickel carbonyl ($Ni(CO)_4$), mercury (Hg) and arsenic (As);
- Other occupational hazards such as noise, heat, and exposure to potentially toxic dusts of nickel and other heavy metals.

4.4.3 Hazard Analysis Matrix

The hazards and risks associated with the various mining and nickel ore processing activities, processes and conditions are listed in the **Hazard Analysis Matrix (**Table 3.1).

Table 3.1. Hazard Analysis Matrix.

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
'A. Nickel Mining			

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
1. Storage of Liquid fuel (Diesel)	Fire and explosion following major releases/ spills	Presence of ignition sources; breach of containment; mechanical impacts; exposure to fires and high heat; corrosion; defective or substandard tank materials; breach of bund walls; vandalism	-Persons, equipment and structures within the hazard area.
2. Waste and overburden dumps and stock yards	-land and rock slides -siltation of surface water bodies; -runoffs from overburden may contain toxic heavy metals and minerals which may contaminate surface water bodies	heavy rains, typhoons, earthquakes, defective engineering design.	-surrounding communities, personnel and workers -ecological entities
3. Settling and Wastewater Ponds	-Breach of containment of ponds and drainage system could cause flooding of low-lying areas; release of heavy-metal contaminated sediments; siltation; and contamination of surface water bodies and possibly ground water with toxic heavy metals and substances.	natural disasters (earthquakes, extreme weather); engineering problems; sabotage	-surface waters -aquatic ecological entities -surrounding communities
4. Occupational Safety Hazards			
a. Site Preparation			

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
(1) surveying	-fall from heights -vehicular accidents	inherent geological formations; adverse weather conditions; human error; vehicular failure	-surveying team
(2) Clearing and Grubbing	-being struck by felling trees, debris and equipment part -vibration and noise from power saws and other equipment -vehicular and equipment accidents (overturning, fall from heights, etc.)	human error; equipment failure; adverse weather conditions	-clearing team
(3) Laying Out	-fall from heights; being struck by vehicles and earth moving equipment -vehicular and earth moving equipment accidents -electrocution	human error, equipment/ vehicular failure breach of protocols	-workers, drivers and operators at site
b. Contour Open Pit Surface Mining Processes			
(1) Drilling and Excavation	-fall from the edge of a bench -being struck by falling rocks/debris at the foot of a face -inhalation of and contact with dusts which predisposes to respiratory and skin	Human error breach of protocols equipment failure face instability	-Drilling operators and assistants

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
	diseases and possibly cancer, -Harmful noise levels -Being struck by a moving part of the drilling equipment		
(2) Nickel Ore Extraction	-inhalation of and contact with dusts, nickel and other toxic heavy metals which could predispose to respiratory and skin diseases and heavy metal-induced diseases.	lack of or inappropriate protective equipment	-Mining pit operators and workers, neighboring communities
(3) Ore Loading	-Being struck by falling rocks from loading arm -falls while gaining access to operator's cabin -vehicular accidents	breach of protocols human error failure of hydraulic system and other equipment uneven ground	-driver, operator, assistants, trespassers
(4) Hauling and Transport of Ores and Overburden	-Vehicular accidents (fall from edge of bench, collision with other vehicles or structures, overturning, etc.) -inhalation of and/or contact with dusts -high level noise	incompetent driving heavy rains and flooding trespassing breach of protocols brake failure	-driver, pedestrians, driver of smaller vehicles,
(5) Ore Stockpiling	-Inhalation of and contact with dusts and heavy metals could predispose to respiratory/skin/eye	airborne dusts especially with strong winds	- workers, nearby communities

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
	diseases and heavy metal-induced diseases.		
c. LCT and ore ship loading/ unloading	-Inhalation of and contact with dusts and heavy metals -vehicular (dump trucks) accidents -LCT accidents -high level noise	airborne dusts during loading/unloading operations insufficient vehicular/equipment maintenance driver error breach of protocols inclement weather conditions	-dump truck operators, stockyard and causeway workers, LCT and ore ship crew
'B. Nickel Ore Processing Into Ferronickel Alloy			
1. Coal	Coal dust fire and/or explosion	Spontaneous combustion; Ignition sources in the vicinity; Activites that create friction in the stockpiles; Confining conditions; Too high volatile contents of the coal; Too high coal fines content; Poor housekeeping leading to accumulation of coal dusts on walls, floors and crevices; Frictional sparks due to foreign materials in the coal feed to the crusher;	-Processing Plant workers, neighboring communities

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
		Poor equipment maintenance; Failure of or inadequate fire detection and control systems; Defective electrical equipment; Sabotage	
2. Fugitive Toxic Fumes and gases			Workers at the Plant
a. Carbon monoxide	An asphyxiant gas; may be fatal if inhaled or absorbed through skin	Defective smelting reactor; Inadequate PPE (e.g. gas respirators, gloves, coveralls); Inadequate equipment maintenance Inadequate or faulty ventillation	Workers at the Plant
b. Nickel carbonyl	Extremely toxic upon acute inhalation exposure; inhalation may cause pulmonary edema; teratogenic and carcinogenic in some laboratory animals		
c. Nickel fumes	Acute inhalation exposure may cause headache, nausea, respiratory disorders and death		
d. Mercury fumes	Toxicity may affect the neurologic, gastrointestinal and renal organ systems		
3. Microwave radiation leaks from smelting reactor	Exposure to high levels of microwave radiation can cause serious burns and tissue damage		Workers at the Plant

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
4. High impact noise	Hearing impairment	Inadequate equipment maintenance; Inadequate hearing PPE	Workers at the Plant
5. Heat	Heat exhaustion/ stroke	Inadequate ventillation	Workers at the Plant
E. Natural calamities due to extreme climate events (as predicted in years 2020 and 2050)			
1. Increased frequency and intensity of tropical cyclones	- flooding of low lying areas; rock and land slides; storm surges and tidal flooding	-poor engineering design and zoning, poor maintenance of structures, defective warning systems; infrastructures along coastlines, riverbanks and flood plains	-personnel and workers of the project; contractors, nearby communities esp. along coastlines and in river banks
2. Increased intensity and frequency of rains during rainy season	-flooding of low lying areas; rock/ land slides; increased soil erosion and loss of fertility; storm surge in causeway	-same as above	-same as above -farmers
3. Sea level rise	-submersion and damage of coastal infrastructures like loading/unloading piers and facilities	-location of infrastructures near coastlines	-same as above
4. Drier dry seasons and increased ambient temperatures	-fire incidents; increased airborne dusts; drying of water reservoirs and sources	-presence of ignition sources, especially near storage of fuel and chemicals; indiscriminate disposal of live cigarette butts -inadequate dust suppression system;	-personnel, workers, contractors, nearby communities

Hazard Classification/ Unit Operation	Major Hazards	Initiating/ Contributing Factors	At Risk Sector
		forest/ vegetation denudation	
F. Natural Calamities due to Earthquakes	-collapse of infrastructues and buildings; spillage of fuel and chemicals predisposing to fires and toxic events; land slides; tsunami	-poor engineering design and zoning; poor maintenance of structures and equipment; location of buildings and other infrastructures along coastlines	-same as above

4.4.4 Risk Screening of Hazardous Substances at the Facility

A risk screening procedure was undertaken to determine the type of environmental risk assessment to be undertaken and to prioritize the environmental risks presented by the various hazardous substances and activities. The criteria and process used in risk screening was primarily based on *Annex 2-7e* (*Guidelines for the Conduct of Environmental Risk Assessment)* of the *Revised Procedural Manual of DAO 2003-30*. The screening criteria for hazardous substances are (1) inherent hazardous characteristics of the substance and (2) maximum quantity involved. After classifying the substances according to defined categories (i.e. flammable, oxidizing, toxic, etc.), their respective maximum inventories were compared to DENR’s threshold inventory levels (Levels 1 and 2), which are defined in the *Revised DAO 2003-30* guideline. A facility that will manufacture, process or store any hazardous substance in excess of DENR's Threshold Inventory Level 2 is required to undertake a quantitative risk assessment. Those with any hazardous substance exceeding Level 1 threshold inventory but below Level 2 threshold inventory is required to undertake Hazard Analysis Study, and Emergency/Contingency Plan based on the study and worst-case scenario. For substances with maximum inventory below Level 1, a risk screening and emergency plan based on hazard analysis is required.

As far as hazardous substance is concerned, the expansion nickel mining component and the ferronickel processing plant will only store and use coal and diesel, substances that are considered as flammables. Diesel will be used as fuel for vehicles, generator sets and equipment at the mine site and at the Plant. For the nickel ore processing, of the various raw materials and substances to be stored and used at the Plant (coal, nickel ores, flux, dolomite), only coal is considered as hazardous. Pulverized coal will be used as reducer in the Low Temperature Reducing Reactor

(LTRR) in ferronickel processing. The Plant is expected to utilize a total 396,000 tons of pulverized coal per annum. Assuming a one-month inventory of coal as the maximum amount to be stored, the Plant will have at most 33,000 tons of coal at the site. This amount is higher than the DENR Level 1 Threshold Inventory of 5,000 tons for flammable substances but lower than the Level 2 Threshold Inventory of 50,000 tons for flammable substances. Maximum inventory of diesel at the Plant site is minimal at approximately 40 m^3 or 33.64 tons. Given these quantities, the Total Indicative Sum (TIS) is only 0.661, a value that is less than unity (1.0). Given these data, the ERA Coverage was determined as Level 1. That is, an Emergency/Contingency Plan is required based on Worst-case scenario analysis.

4.4.5 Hazardous Characteristics of Bituminous Coal

4.4.5.1 Environment and Health Hazards

Coal dust explosion and fire are among the major hazards associated with coal storage and utilization in plants. Coal is classified as a combustible material. Coal contains a complex mixture of variable amounts of volatile combustible matter, which are released or volatilized at high temperature in the absence of air. The presence of coal dust and the co-presence of methane, a flammable gas, influence the potential of coal for flammability. In coal utilization, it is the process, rather than the coal itself, that may present fire and explosion hazards. Further, the flammability of coal could vary with its origin (geological characteristics), the percentage of volatile matter and the calorific value, factors that influence the ease of combustion (Bingham, 2001). Although it has been demonstrated that methane and other short-chained hydrocarbons (ethane, ethylene, propane, propylene and butane) may be present in coal with no apparent methane emission, the amount of these residual gases is very minimal. Based on the study by Kim and Douglas (1973), the amount of residual gases in coal merely ranges from 0.0007 to 0.524 ft^3/ton of coal (Douglas., 1973).

Coal dust explosion requires the following five necessary elements, referred to as the explosion pentagon, to occur concurrently: fuel, heat, oxygen, suspension, and confinement. It should be noted that the first three elements (fuel, heat and oxygen) compose the so-called fire triangle. Removing any one of the five elements would prevent an explosion from propagating. For the fuel element, there are three prerequisites for coal dust to be explosive: (1) a volatile ratio exceeding 0.12, (2) particle size of 841 microns (0.841 mm) or less, and (3) the quantity of coal dust available at least meet the minimum explosive concentration (MEC), the quantity of dust in suspension that will propagate a coal dust explosion and generate sufficient pressure to cause damage. MEC for bituminous coal is approximately 100 grams per cubic meter. A person cannot breathe in an atmosphere containing dust at MEC. A layer of coal dust on the floor with potential to be at MEC if suspended is around 0.00127-mm thick, enough for footprints to be visible. Also, if coal dust is visible on the walls of a plant, it is considered to be enough to propagate an explosion (Stephan).

Coal dust explosion hazard increases with decreasing coal particle sizes. Particle sizes of coal that can propagate a dust explosion may occur within cyclone dust collectors, coal mills, dust collectors/baghouses, and coal feed bunkers/bins (Alameddin and Luzik, 1987). Coal dust explosion may be triggered by spontaneous coal dust combustion or by ignition sources such as sparks. In coal feed bunkers fires may be triggered by unplanned shutdowns and power interruptions. During such events, coal in the bunker may undergo spontaneous combustion because of prolonged residence time. Exothermic reaction is accelerated in the confined space of the bunker, which could lead to uncontrolled heating and eventually to spontaneous combustion (General Electric, 2013).

Electrical or frictional sparks can also provide the heat source to initiate a fire or explosion, even in the absence of methane. All coal dusts are predisposed to ignition when exposed to the frictional sparks of badly maintained machinery or in the presence of contaminating tramp metal (Stephan, n.d.).

Studies on the causes of coal dust explosion accidents on coal-fired power plants show that coal-fired power plant equipment with the highest coal dust explosion potential are the following: coal pulverizer, dust collector, cyclone, electrostatic precipitator, coal storage bins and silos, and transport pipes and ducts connecting the vulnerable equipment. Of these equipment, the dust collectors (bag houses) had the highest frequency of explosion accidents. Causes of and predisposing factors to coal dust explosion include the following (Fike Corporation, 2001; FM Global Property, Jan. 2000; General Electric, 2013):

- Unplanned shutdowns and power interruptions leading to prolonged coal residence time in feed bunkers, which could lead to spontaneous combustion, fire and/or explosion;
- Failure of inert gas source in coal pulverizer, introducing air and subsequently igniting collected pyrites below the pulverizing bed;
- Failure to follow inerting procedures;
- Sparks created by foreign objects (eg. tramp metals and spikes) in the coal feed;
- Ignition created by uncontrolled high static electricity in the dust collector due to typically high temperatures and coal dust suspension;
- Entry of sparks, flames or smoldering embers from dust production areas into vulnerable equipment, particularly dust collectors, cyclones or electrostatic precipitators;

- Continuous spark generation and mechanical rapping in electrostatic precipitators serve as inherent sources of ignition;
- Poor equipment maintenance (eg. broken fans can generate frictional sparks); and
- Poor housekeeping can lead to build up of coal dusts in bunkers, crusher house, hidden crevices and others, predisposing to coal fire and explosion.

Coal dust explosion in open areas where coal is massively stored or handled, as in the stockyard, is highly unlikely due to the absence of the confinement element of the explosion pentagon. The coal stockyard is simply a roofed but open area that is well ventilated and far from combustible structures and populated areas. The worst-case accident scenario that could occur at the stockyard is a flaming fire resulting from uncontrolled/unchecked smoldering of coal. Uncontrolled smoldering/combustion of coal dust below the surface can volatilize flammable gases from the volatile combustible matter of coal to generate flames that may spread rapidly on the surface. The component of coal that will take part in the combustion process will be limited to the volatile combustible matter.

4.4.6 Hazardous Characteristics of Diesel

Diesel is a moderately flammable liquid fuel. The National Fire Protection Agency (NFPA) of the U.S.A. assigns to diesel a Flammability Rating 2 (ignites when moderately heated). Distillation temperature of diesel at 90% point is between 282-338^{o}C. Its minimum flash point temperature is 52^{o}C. Its other physic-chemical and toxicological properties are listed in *Table 151*. Fuel oil is less flammable than diesel.

Table 151 - Physico-chemical and toxicological properties of diesel.

Property	Value/ Description
CAS RN No(s).	68334-30-5; 68476-30-2; 68476-31-3
UN Number	1993
Maximum Inventory at the Site	50 m^3
Flammability Designation/Code	Moderately Flammable
Flash Point, ^{o}C	52
Lower flammability limits in air (%)	1.3
Upper flammability limits in Air (%)	6

Property	Value/ Description
Autoignition Temperature, °C	254-285
Boiling/Condensation point (°C) at 1 atm	282-338
Specific gravity (liquid)	0.841 at 16°C
Vapor pressure	0.0028 bar at 21°C

Sources: CAMEO Chemical Inventory; NREL Liquid Fuels Database, 2007.

4.4.6.1 Fire and Explosion Hazards of Diesel

Vapor cloud explosions and vapor cloud fires are not significant hazards to this particular substance and activity due to the low vapour pressure of the liquid (0.042 psia at 21°C). The more probable accident scenario for this type of substance is a pool or tank-top fire.

Hazards from fires are associated with their direct heating effect, by convection within the fire itself, and thermal radiation from the fire. In case of fire engulfment, the effects of fire on humans are usually on the skin and on the lungs. Smoke rather than the fire itself is the most common cause of death indoors. Fires emit radiation, which can produce considerable impact on nearby equipment and may cause harm to people. Thermal radiation levels and their damaging effects on equipment and people are described in *Table 152* (CCPS-AIChE, 1994).

Table 152 - Effects of radiation from fire.

Incident Flux (KW/m^2)	Type of Damage Caused	
	Equipment	People
37.5	Damage to process equipment (steel structure, piping, vessels, etc,) after several minutes of exposure.	100% fatality in 1 min.; 1% fatality in 10 sec.
25.0	Minimum energey level to ignite wood at indefinitely long exposure without flame	100% fatality in 1 min.; Significant injury in 10 sec.
12.5	Minimum energy to ignite wood with a flame; melts or degrades plastic materials	30% fatality in 1 min.; 1st degree burns in 10 sec.
10.0		People will feel pain after 5 seconds and receive second-degree burns after 14 seconds. Usually used to define the fatality zone, as this level is expected to

Incident Flux (KW/m²)	Type of Damage Caused	
	Equipment	People
		quickly cause third degree burns leading to potential fatalities
5.0		People will feel pain after 13 seconds and receive second-degree burns after 40 seconds. Usually used to define the injury zone.

Sources: Taylor, 1994; USEPA, et al., 1990; World Bank Technical Paper No. 55.

4.4.6.2 Health Hazards of Diesel

The NFPA Health Hazard Rating of Diesel is 1 (slightly hazardous). This slight health hazard is mainly attributable to its volatile organic compound components (VOCs) which comprise about 1.5% of its total weight. These VOCs are benzene, toluene, ethylbenzene, xylene and other alkylbenzenes. The acute effects of exposure to high level concentration of various solvents are generally very similar. High level exposure usually results to disorientation, euphoria, giddiness and confusion, progressing to unconsciousness, paralysis, convulsion, and death from respiratory or cardiovascular arrest. Chronic exposure to levels above the threshold level values may result to specific organ toxicity. The hazardous VOC components of diesel, which may exert deleterious health impacts, are benzene, toluene, ethylbenzene and xylene.

Benzene is a proven human carcinogen. It is classified as a very hazardous substance. Toxicity to benzene frequently results from inhalation of its vapors with some undefined contribution from skin absorption. Acute exposure to high levels of benzene vapors may result to depression of the central nervous system, leading to unconsciousness and death, or death through cardiac arrythmias. The major toxic effect of benzene, however, is its hematopoietic toxicity resulting from chronic exposure to benzene vapors. Among the simple aromatic hydrocarbons, hematopoietic toxicity is unique to benzene. Chronic exposure to benzene leads to bone marrow damage, which may show initially as anemia, leukopenia, or thrombocytopenia. Continued exposure may result in pancytopenia which may eventually lead to bone marrow aplasia, a usually fatal condition. Bone marrow depression induced by benzene appears to be dose- and time-dependent. Leukemia induced by exposure to benzene has been noted in humans. In mice and rats, chronic benzene exposure through inhalation and per oral has been shown to produce solid tumors in nonhematopoietic organs.

Alkylbenzenes. Alkylbenzenes like toluene, ethylbenzene, isoprppylbenzene, trimethylbenzene and xylene are relatively non-toxic except during acute exposure to high concentrations. This could be because their major metabolic pathway is toward metabolites that have low toxicity and are readily excreted. Unlike benzene, they have not been demonstrated to be carcinogenic. Acute exposure to very high levels of these substances could result to acute toxicity manifested by central nervous system (CNS) depression, symptoms typical of acute solvent toxicity. Long term exposure could lead to CNS function impairment (Cragg et. al. 1989; Bardodej and Cirek 1988).

4.4.7 Mass Movement of Rocks and Soil from Overburden and Waste Dump Sites

Waste rocks and soil materials generated from mining and beneficiation/ sizing activities to be disposed into a series of waste dump stockpiles or used as backfill. Major hazards associated with mine waste dumps are mass movement of rocks and soil (eg. landslides and rockslides), soil erosion and runoffs. Such events could be initiated by natural hazards such as earthquakes, heavy rains and typhoons, and breaching of berms. Rock slides and landslides can result to loss of lives and injuries, siltation and contamination surface waters, and damage to terrestrial and aquatic environments. The waste dumps may contain high concentration of heavy metals such as nickel (Ni), chromite (Cr), cobalt (Co), cadmium (Cd), iron (Fe), lead (Pb), mercury (Hg), arsenic (As) and copper (Cu). Many of these metals have the potential to exert toxic impacts on people, flora and fauna. The disturbed condition of soil and rocks at mine sites also predisposes to mass movement of rocks and soil at the site, especially during inclement weather conditions and earthquakes. Such events could put to risk the workers at the site, as well as the mining equipment.

4.4.8 Flooding and Mass Release of Sediments from Settling Ponds

The expansion nickel mining project will be equipped with drainage systems that will drain into settling ponds to mitigate the impacts of surface runoffs that could lead to soil erosion, siltation and pollution of water bodies. Breaching of settling ponds could lead to flooding and mass release of sediments that may be heavily tainted with heavy metals and minerals. Factors that may contribute to such accidents are natural hazards like strong earthquakes, long duration heavy rains, strong typhoons, faulty engineering design, and sabotage.

Mass release of sediments and flooding can result to injuries, heavy siltation of affected surface water systems, and destruction and contamination (with heavy metals and minerals) of affected terrestrial and aquatic environments.

4.4.9 Occupational Safety Hazards

Occupational safety issues involving the project are listed in the Hazard Analysis Matrix (Table 3.1). Occupational safety issues associated with nickel mining activities include fall from heights; rock falls and soil movement accidents; vehicular/equipment accidents; being struck by equipment parts, debris, etc.; respiratory, eye and skin ailments; and hearing impairment due to high intensity noise.

4.4.10 Exposure to Toxic Heavy Metals and Minerals

Mining activities are expected to increase the loads of heavy metals and other toxic substances in the vicinity and at the site. Mining wastes are expected to contain toxic heavy metals and minerals such as nickel, chromium, cadmium, cobalt, iron, manganese, mercury, lead, copper, zinc, aluminum, selenium and arsenic. Heavy metals may be washed off from the ores and mining wastes as a result of runoff. Workers who are involved in the extraction and processing of nickel ores are likely to get exposed to these toxic substances, especially to nickel, through skin contact and inhalation of dusts. The toxicological hazards of these substances are summarized in *Table 153***.** The toxicological character of the identified heavy metals and minerals are subsequently discussed.

Table 153 - Heavy metals and other hazardous substances in nickel mining.

Substance	Effects and Significance
Nickel	Carcinogenic; may induce contact dermatitis; may affect male and female reproductive capacity
Iron	Essential nutrient; damages fixtures by staining; partly responsible for acid mine drainage
Chromium	Essential as Cr(III), toxic as Cr(VI)
Cobalt	Toxic effects on vascular system and male and female reproductive organs
Arsenic	Toxic, possibly carcinogenic
Copper	Essential trace element; toxic to humans, plants and algae at higher levels
Lead	Toxic, harmful to humans and animals, carcinogenic
Manganese	Toxic to plants, damages fixtures by staining
Mercury	Toxic, mobilized as methyl mercury compounds by anaerobic bacteria

Substance	Effects and Significance
Zinc	Essential element, toxic to plants at higher levels

4.4.10.1 Nickel (Ni)

Nickel may be an essential trace metal in mammals, as it is involved in glucose metabolism. Excess nickel, however is toxic to life forms. Nickel is a respiratory tract carcinogen, the incidence of which is significantly higher among workers in the nickel refining industry. Nickel may also induce contact dermatitis (Goyer, 1996). Severe acute and sometimes fatal toxicity may follow exposure to nickel carbonyl, a highly toxic intermediate by-product of nickel smelting. Workers may become exposed to highly toxic nickel carbonyl through fugitive fumes which may escape the a defective or substandard nickel ore smelting reactor.

Nickel is slightly absorbed through the gastrointestinal tract. It is transported in the plasma bound to serum albumin and a host of other small organic ligands, amino acids or polypeptides. Excretion in the urine is complete in 4 to 5 days. Environmental nickel or nickel concentration in ambient air influences serum nickel concentration. A study of people living near a large nickel mine in Ontario revealed serum nickel levels of 4.6±1.4 ug/L, with range of 2.0 to 7.3 mg/L, and urinary concentrations of 7.9 ± 3.7 ug/day (range 2.3 to 15.7 ug/day). Fecal nickel is generally 100 times the concentration in urine (Goyer, 1996).

Occupational exposure to nickel predisposes humans to lung and nasal cancer. There are also evidence of increased risks from laryngeal cancer in nickel refinery workers in Norway and gastric carcinoma and soft tissue sarcomas from the Soviet Union. Increased risks from renal cancer had also been reported among nickel refinery workers in Norway and Canada. Increased risks from respiratory tract cancer had also been detected among nickel refining workers. Studies indicate that the increased risk of cancer among the nickel refining workers could be attributable to nickel subsulfide (Ni_3S_2) and nickel sulphate ($NiSO_4$), substances which are present in the nickel molten ore (Goyer, 1996). Nickel carbonyl [$Ni(CO)_4$], an extremely toxic intermediate product of nickel refining, accounts for many cases of acute toxicity among nickel refining workers.

Nickel dermatitis is one of the most common forms of allergic contact dermatitis. Increased ingestion of nickel-containing food increases the probability of external sensitization to nickel and eventually the episodes of acute nickel dermatitis (Goyer, 1996). Nickel is also reported as affecting male and female reproductive capacity (Thomas, 1996).

4.4.10.2 Iron (Fe)

Elemental and iron compounds are usual components of nickel ores and mining wastes. In fact, limonite type of lateritic nickel is highly enriched in Fe. Iron is an essential element to human and animal metabolism in trace amounts. In excess, it can exert toxic effects and environmental impacts. The iron compound pyrite (FeS2) is partly to blame for acid mine drainage, one of the most common and damaging problems in the aquatic environment. Acid mine water is a consequence of the presence of sulfuric acid produced by the oxidation of pyrite, a process that occurs very slowly at low pH conditions. Below pH 3.5, the iron oxidation is catalyzed by the iron bacterium Thiobacillus ferrooxidans, and in the pH range 3.5-4.5 it may be catalyzed by a variety of Metallogenium, a filamentous iron bacteria. The beds of streams afflicted with acid mine drainage are usually covered with "yellowboy", an unsightly deposit of amorphous, semigelatinous Fe(OH)3. The product sulfuric acid is however the most damaging component of acid mine water. It is directly toxic to organisms and plants (Manahan, 1994).

4.4.10.3 Chromium (Cr)

The process of nickel mining may facilitate the release of chromium to the environment. Chromium is extracted from chromite ore, the molecular formula of which is [(Fe, Mg)O(Cr, Al, Fe)2O3]. The largest deposits of chromite are located in the Philippines, South Africa, the former USSR, southern Zimbabwe and Turkey (Losi et al., 1994). Chromium in trace amounts is an essential element of human and animal nutrition. It is important in glucose and fat metabolism. Trivalent Cr is the nutritionally useful form while the hexavalent form is toxic and mutagenic. The biotoxicity of chromate is mostly a function of its ability to cross biological membranes and its powerful oxidizing capabilities. Cr(VI) compounds can be absorbed by humans through inhalation, dermal contact, and ingestion. Excessive Cr exposure can result to ulceration and perforation of the nasal septum, respiratory cancer, skin ulceration, contact dermatitis, and in the event of ingestion, kidney damage. It can also cause damage to various proteins and nucleic acids, which can lead to mutation and carcinogenesis (Lewis and Bianchi, 1982).

4.4.10.4 Cobalt (Co)

Like the other heavy metals selenium, chromium, copper, zinc, cadmium, lead and mercury, cobalt is known to exert toxic effect on the vascular system through blocking of the calcium channels and through reactions with the sulfhydryl, carbonyl, or phosphate groups (Ramos et al., 1996). It is also known to be toxic to the male and female reproductive capacity like the heavy metals aluminium, boranes, boron, cadmium, lead, mercury and nickel. Excess of Cobalt has been demonstrated to cause testicular toxicity through inhibition of DNA synthesis Thomas, 1996).

4.4.10.5 Arsenic (As)

Arsenic may form part of the mining waste. Arsenic is a general cytotoxicant which can elicit injury to most cells and organ systems. It chelates with alpha-lipoic acid, disrupting energy production from the Kreb Cycle. Alpha-lipoic acid is an essential co-factor for pyruvate dehydrogenase, an enzyme required in the Kreb Cycle. Arsenic is mostly in the form of arsenate in the biological system. It mimics the phosphate oxyanion in cells. "Substitution" of phosphate by arsenate effectively disrupts a variety of metabolic reactions, resulting in the inhibition of ATP formation. The general effect is toxicity to the cells (Chang and Cockerham, 1994).

4.4.10.6 Mercury (Hg)

Mercury may also form part of the mining waste. Mercury is a naturally occurring element present in rocks and ores. It is found as a trace component of many minerals, with continental rocks containing an average of around 80 ppb. It often has significant correlation with carbon, sulphur and zinc. Its concentration varies with location depending on the nature of the bedrock and degree of mineralization. Up to as much as 1000 ug/g maybe contained in some ores. The general terrestrial concentration of mercury appears to be in the order of 0.05 ug/g (Wren et al., 1995). Mercury is well-known to bioaccumulate or bioconcentrte in aquatic food chains. Bioaccumulation occurs because mercury when methylated, is very effectively absorbed by a variety of aquatic organisms. Unlike in aquatic ecosystems, bioaccumulation of mercury in terrestrial ecosystems is relatively low.

Inhalation of mercury vapour (elemental mercury) may produce acute, corrosive bronchitis and interstitial pneumonitis. If not fatal, it may be associated with central nervous system effects such as tremors or increased excitability. Exposure to inorganic mercuric ions increases risks of kidney damage. Mercury vapour and organomercury are potent neurotoxicants. Methylmercury is well-known as an extremely toxic substance in the environment. The sysmptoms of methylmercury poisoning (Minimata disease) are mainly neurological in nature. It includes ataxia, constriction of visual field, sensory disturbance, impairment of speech, impairment of hearing , tremors, metnal disturbance, and many others (Chang and Cockerham, 1994).

4.4.10.7 Manganese (Mn)

Manganese may also constitute one of the heavy metal wastes of mining. This metal is neurotoxic and could induce Parkinson-like syndromes and degeneration of the caudate nucleus, basal ganglia, and substancia nigra (Chang and Cockerham, 1994).

4.4.11 Natural Hazards Due to Extreme Climate Events

The increasing frequency and intensity of extreme climate events are being attributed as direct consequences of global climate change, which is primarily due to global warming. As stated by the Manila Observatory (2010) in its paper Technical Primer on Climate Change in the Philippine, "Climate change will increase the magnitude and frequency of weather hazards to an unknown degree". This phenomenon poses an increased risk of disasters in the Philippines, as risk is not only proportional to the magnitude of events but on the number of people affected and their capacity to recover from the impacts of an event.

Other direct impacts of climate change in the Philippines are significant increases in frequency of high extreme ambient temperature (>35oC), which manifests as significant increase in the frequency of hot days and warm nights; drier dry seasons; and wetter rainy seasons. Based on climate modeling conducted by PAGASA for the various regions of the Philippines, annual mean temperatures are expected to rise by 0.9 degrees Celsius to 1.1 degrees in 2020 and by 1.8 degrees to 2.1 degrees in 2050" (Hilario, et al., n.d.). PAGASA likewise predicted that "the drier seasons of March-April-May will become drier still, while the wetter season of Sept- Oct. and November will become wetter" (Hilario, et al., n.d.).

4.4.11.1 Projected Hazards by 2020

The projected increased rainfall intensity during the wet months implies greater risks from hazards brought about by flooding, landslides, soil erosion, siltation of surface water bodies, and loss of soil fertility. The unusually drier periods during the dry months, coupled with ambient temperature extremes, implies greater risks from fire, low water supply, greater airborne dusts, drying up of water reservoir, and dry season related diseases (i.e. respiratory ailments, heat strokes, etc.).

4.4.11.2 Projected Hazards by 2050

The period from 2036 to 2065 is predicted to experience a decrease in rainfall in the months of March to May. The rest of the months will experience increases in rainfall, with the rainiest months being September to November. The decrease of rainfall in the dry months, coupled with increased frequency in the occurrence of high extreme temperatures, could result to greater risks from drying up of surface water bodies, fire, greater airborne dusts, and diseases that thrive during the dry and hot seasons (i.e. respiratory ailments, heat strokes, prickly heat, nose bleeding, exacerbation of heart conditions, etc.). Assuming that the mining operations in the area is still ongoing, this could also mean greater risks from occupational safety and health hazards, as workers become more prone to fatigue, dizzy spells, dehydration, and heat stroke in extremely hot conditions. They may also suffer more from skin irritations and contact dermatitis, due to increased sweating and more airborne dusts. The temperature rise is expected to bring about an increase in the frequency, strength and range of tropical cyclones (Manila Observatory, 2010).

4.5 ***Worst-Case Accident Scenario Analysis for Coal Dust Explosion in Pulverized Coal Feed Bin***

This scenario was chosen as the worst-case accident scenario for coal dust explosion at the ferronickel processing plant as the coal feed bin contains the biggest quantity of pulverized coal at this facility. The quantity of pulverized coal that would be involved in the explosion in the silo was assumed to be the maximum amount of pulverized coal contained in a feed bin, which has a volume capacity of 4 m3. The bin could contain a maximum amount of 2,244 kg of coal, assuming a coal density of 561 kg/m3.

Coal dust explosion was modeled as Unconfined Vapor Cloud Explosion (UVCE) that occurred secondary to a primary explosion that occurred inside the bin, which subsequently damaged it, releasing the entire contents of pulverized coal. The released contents subsequently ignited and exploded. Consequence calculation was done by first computing for the TNT equivalent mass of the coal dust involved. Then, distances for potential overpressure impacts were computed using the base equation used in the ARCHIE model for Unconfined Vapor Cloud Explosion. The equation used to compute for the TNT equivalent mass is described in the Handbook of Chemical Hazard Analysis Procedures (FEMA, et al, 1989, p. B-44) and is designated as Equation No. B.55.The equation is as follows:

$$\mathbf{M_{TNT} = M_{cloud} * (H_c/1155) * Y_f}$$

Where:

M_{TNT} = TNT equivalent mass, lbs

M_{cloud} = Mass of coal dust in cloud, lbs

H_c = Lower heat of Combustion of coal, kcal/kg

Y_f = Yield factor (assumed as 0.03)

The bases for the computation of the TNT equivalent mass (M_{TNT}) are shown in *Table 154*.

Table 154 - Bases for the computation of the TNT equivalent mass for postulated coal dust explosion at the pulverized coal silo.

Parameters	Value	References/ Comments
Mass of pulverized coal in a feed bin (Assumed at 100% full; 4 m^3 capacity)	2,244 kg (4,947 lbs)	Max capacity (2,244 kg)
Mass in cloud (M_{cloud}) (assumed 70%)	1,571 kg (3464 lbs)	
Heat of combustion (H_c)	4,565kcal/kg	
Yield factor (Y_f)	0.03	FEMA, et al., 1989.; EC, 2015
Heat of TNT detonation (H_{TNT})	1155 kcal/kg	FEMA, et al., 1989
TNT Equivalent mass (M_{TNT})	186 kg (410 lbs)	Computed

Results of the calculations for the various distances to specified overpressure impacts and their relevance are in Table 4.2. The said distances are expectedly overestimated since the impediments posed by the walls of the silo and other structures are not taken into account in modeling.

The distance from the point of a ground-level explosion to peak overpressure was calculated using Equation B.56 in the Handbook of Chemical Hazard Analysis Procedures, which was developed for the ARCHIE model (FEMA, et al, 1989, p. B-45). The said equation is used in the ARCHIE model for the Unconfined Vapor Cloud Explosion and also used by the USEPA in its Risk Management studies. The equation assumes an explosion at ground level without redirection of the overpressure by structures and terrain. The distance "X" would be reduced by a factor of 1.260 if it should occur up in the air (unconfined in all directions). As the dust explosion is assumed to take place above-ground (the silos are above ground), the reduction factor of 1.260 was applied on the derived distance to overpressure ("X"). The equation for the distance to peak overpressure is as follows:

$$\mathbf{X = M^{1/3}}\boldsymbol{exp}\mathbf{[3.5031 - 0.7241*}\boldsymbol{ln}\mathbf{P + 0.0398*(}\boldsymbol{ln}\mathbf{P)^2\,]}$$

where, **X** = Distance in feet to a given overpressure, P

M = TNT equivalent mass, lbs

P = overpressure, psi (psi = pounds per square inch)

Using the earlier computed TNT equivalent mass of coal dust (186 kgs or 410 lbs), distances to various explosion overpressure endpoints were calculated. Results of the calculations are shown *Table 155*.

Table 155 - Computed Distances to the Various Overpressure Endpoints for the Postulated Coal Dust Explosion at the Pulverized Coal Silo

Explosion Overpressure (psi)	Expected Damage/Relevance[5]	Max. Distance to Endpoint (m)	Number Potentially Injured Persons (External)
1.0	Possible serious injury due to flying glass and missiles; Probability of injury is 10%; Fatality not expected.; Partial demolition of houses; Usually used as the threshold overpressure value for regulatory purposes by USEPA; Used to delineate the maximum Injury Zone.	60	0
3.0	20% chance of fatality to a person in a building. Used to Delineate the maximum 20%Fatality Zone.	28	0
5.0	Nearly complete destruction of houses; Threshold of eardrum damage; 50% chance of fatality for a person in a building and 15% chance of fatality for a person in the open. This delineates the 50% Fatality Zone.	21	0
10.0	Threshold of lung damage; 100% chance of fatality for a person in a building or in the open; Complete demolition of houses. This delineates the **100% Fatality Zone**.	14	0

[5]"Guidelines for Hazard Analysis."Advisory Paper No. 6, Department of Planning. Sydney, Australia.

Summary of Consequences. The maximum distance to the threshold overpressure for possible serious injuries (1.0 psi)[6] is 60 meters, corresponding to a hazard zone that is confined within the perimeters of the project site. The overpressure that may possibly result to 20% chance of fatality of persons within a building (3.0 psi) covers a radius of 28 m from the center of explosion. For purposes of this assessment, this radius will be regarded as the ***20%fatality radius*** for persons within buildings. The hazard radius for threshold lung damage and 100% fatality to persons within a building or in the open is 14 meters. All hazard distances are confined within the perimeters of the Plant and are not expected to affect any external receptors. The hazard distances may affect persons within the specified distances inside the Plant facility.

4.5.1 Frequency Analysis

Frequency analysis is not necessary in worst-case accident scenario analysis.

4.5.2 Risk Characterization

Based on the results of the worst-case scenario analysis of coat dust explosion originating from the pulverized coal feed bin (contains the highest amount of pulverized coal within the facility), the longest explosion hazard distance that may cause significant injuries (not fatal, mainly due to flying glass and debris) is 60 meters, a radius that is well within the Plant premises. The distance to 3.0 psi, an overpressure that may cause 20% fatality to persons within a building, is 28 meters, while the hazard radius that may cause 100% fatalities for persons within or outside a building (10 psi overpressure) is 14 meters. All hazard distances are expected to be confined within the Plant premises.

4.6 Risk Management

The risk assessment conducted showed that risks expected from the project are relatively low and can be prevented and/or controlled with application of appropriate mitigation measures. In particular, risk from explosion and fire hazards associated with pulverized coal storage and coal utilization are low and are confined within the Plant premises. Other hazards identified are mass movement of rocks and soil, flooding and mass release of sediments from settling ponds, exposure to toxic heavy metals, occupational safety hazards, and natural calamities for the nickel mining project component. For the nickel ore processing component, risks are associated with the storage and use of coal as raw ingredient (reducer) in ferronickel alloy production; possible

[6] USEPA uses 1.0 psi as the threshold limit for possible serious injuries in risk assessment modeling and for regulatory purposes.

emissions of fugitive toxic gases and fumes such as carbon monoxide, nickel carbonyl and heavy metal components of the nickel ore (nickel, chromium, mercury, zinc, others); exposure to high intensity noise, heat, high voltage electricity and microwave radiation; and fugitive dusts from coal, nickel, silicates and flux.

The control and prevention of project-associated risks is dependent on the Company's resolve and capability to pursue their risk management and emergency plans. It would be for the interest of the Company and the surrounding communities that identified risks be appropriately mitigated and/or prevented. Major considerations in risk reduction are appropriate project design; compliance with standards in the design, construction and maintenance of the mining equipment and facilities; well-maintained safety systems; well-trained and motivated workforce; and the establishment of an appropriate emergency response and contingency systems.

To prevent and/or control the identified risks and hazards in its expansion nickel mining project component in Zambales, WestChinaMin should continue to vigorously pursue the implementation of its Safety and Health Program and its Emergency Preparedness and Response Plan that are already in place for the implementation of its existing nickel laterite mining in the area. For the proposed establishment and operation of a nickel ore processing plant that will produce ferronickel alloy, the Company should institute appropriate Safety Policies and Guidelines for the operation of the Plant.

4.6.1 Summary and Recommendations

Hazards associated with the nickel laterite mining project component are mass movement of soil/rocks from waste dumps and mine sites; mass release and/or leaching of heavy-metal contaminated sediments from settling ponds; flooding; occupational safety hazards; fire/explosion hazards from storage liquid fuel (diesel), exposure to dusts and toxic heavy metals; siltation and contamination of surface water bodies with heavy metals; soil erosion and loss of soil fertility; and natural calamities, especially during extreme climate events. Exposure to heavy metals and minerals from mining activities and wastes may exert toxicity impacts to people, animals and plants in the affected areas. For the nickel ore processing component, hazards include potential for coal dust explosion; fire/explosion rom storage and use of liquid fuel (diesel); potential emission of fugitive toxic gases and fumes such as carbon monoxide, nickel carbonyl and heavy metal components of the nickel ore (nickel, chromium, mercury, zinc, others); exposure to high intensity noise, heat, high voltage electricity and microwave radiation; and fugitive dusts from coal, nickel, silicates and flux.

Occupational safety hazards may occur at the various operation units from mining project site preparation to barge/ship loading and in nickel ore processing. Outcome of occupational safety hazards include deaths and injuries resulting from ground/structure failure, fall from heights, being struck or crushed by equipment parts or falling rocks/debris, vehicular/equipment accidents, and others. Mass movement of soil and rocks may occur at waste dumps, mine sites and in disturbed elevated areas. Mass release of contaminated sediments and flooding may arise mainly due to breach of containing walls of impoundment and dikes especially at settling ponds and overburden storage facilities. Such incidents may be triggered by natural events such as extreme climate events (torrential rains, strong typhoons, storm surges, etc.) earthquakes and subsidence; faulty engineering design; inadequate maintenance of structures; and sabotage. Water contamination could result from the release of heavy metals, minerals, and mining overburden and wastes to water bodies. The surface water bodies could also become heavily silted and contaminated with heavy metals. Fire/explosion hazards may arise from the storage and utilization of coal and liquid fuel (diesel).

The consequence analysis for the worst-case accident scenario, which was identified as explosion hazard due to coal storage and utilization, showed that the maximum hazard radius for potentially serious non-fatal injuries (defined by explosion overpressure of at most 1.0 psi) is 60 meters. The identified hazard zone is well within the plant premises.

Particular recommendations to mitigate and manage identified hazards are listed in *Table 156*.

Table 156 - Identified hazards and corresponding mitigating measures.

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
A. Fire and Explosion		
1. Liquid Fuel Storage (Diesel)	Fire following major releases/ spills	-Remove/reduce ignition sources in the area. -Ensure regular inspection and maintenance bund containments (bund capacity should at least be 110% of the tank's capacity). -Ensure regular inspection and maintenance of tanks, pipings, hoses, valves, gauges and other accessories. -Maintain a safety radius or buffer zone around the facility.

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
		-Ensure provision of fire control devices and systems. -Ensure strict adherence to Emergency Preparedness and Response and Plan (EPRP) -Ensure maintainance of properly functioning fire trucks, fire extinguishers and other fire-fighting equipment.
2. Coal Stockyards	• Coal fire/explosion	• Observe proper stockpiling procedures to avoid creation of frictional sparks; • Ensure that no ignition sources are in the vicinity of the stockpiles; • Avoid confining conditions in the stockpiles; • Ensure that delivered coals are compliant with set specifications, especially on % volatile contents and % coal fines; • Ensure the security of the stockpiles from trespassers; • Ensure timely maintenance of conveyor system and other equipment in the stockyard; • Equip stockyards with fire detection and control systems (eg. automatic water spray system, CO and smoke detectors) • Good housekeeping to avoid accumulation of coal dusts, especially in confined places.
3. Coal Crusher/ pulverizer	• Coal dust fire/explosion	• Ensure that no foreign objects are introduced into the equipment to avoid frictional sparks (use of metal detectors and magnets to remove tramp iron); • Proper inerting of the system (use of O_2 deficient air under normal operating conditions); • Equip with temperature sensor and fire detection and control systems; and • Contain the system or equip with an explosion suppression system
4. Coal Dust Collectors, Pulverized coal silos/bins, Electrostatic Precipitators	• Coal dust fire/explosion	• Protect with either explosion venting and/or explosion suppression systems; • Use of appropriate isolation system to prevent flame propagation to other equipment; • Equip with appropriate fire detector, control and fire suppression systems;

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
		● Ground dust collector bags or use semiconductor bags to prevent static electricity discharge; ● Equipment design should be compliant with local and international fire/explosion standards and codes.
5. Nickel Ore Processing Reactor	Fugitive emissions of toxic gases/vapors (CO, nickel carbonyl) and heavy metal fumes (nickel, iron, mercury, chromium, cobalt, etc.)	● Ensure that the Plant and equipment designs are compliant with local and international industry standards and codes; ● Ensure the regular testing and maintenance of the ferronickel processing reactor and all equipment involved in ferronickel alloy production; ● Ensure the provision and wearing of appropriate PPEs (e.g. gas respirators, gloves, goggles, coveralls) in critical processing areas; ● Ensure that industry standard ventillation systems are installed and regularly maintained; ● Install monitoring equipment to detect fugitve emissions of toxic gases, vapors and fumes, particularly of CO, Nickel carbonyl and heavy metal fumes; ● Regular monitoring for possible emission of fugitive gases, vapors and heavy metal fumes
B. Flooding and Mass Movement of Rocks and Soil		
1. Waste Overburden Dumps and Mine sites	-land and rock slides -siltation of surface water bodies; -runoffs from overburden may contain toxic heavy metals and minerals which may contaminate	-Ensure regular inspections and proper maintenance of containment berms. -Batter off final waste dump slope to at most 20 degrees. -Use wastes and overburden as backfill. -Ensure implementation of rehabilitation plan on waste dumps. -Ensure proper siting of the overburden/waste storage facility.

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
	surface water bodies	
2. Settling Ponds	-Breach of containment of ponds and drainage system could cause flooding of low-lying areas; siltation and contamination of surface water bodies and possibly ground water with toxic heavy metals and substances.	-Ensure appropriate siting, design and construction of the facilities. -Ensure regular, as well as emergency inspections and monitoring of structures -Ensure proper and regular maintenance of the facility. -Strictly implement security measures to prevent sabotage of infrastructures.
C. Occupational Hazards		
1. Site Preparation		
a. surveying	-fall from heights -vehicular accidents	-Ensure that vehicles used are well maintained and suitable for the terrain. -Strictly implement safety protocols.
b. Clearing and Waste Stripping	-being struck by felling trees, debris and equipment part -vibration and noise from power saws and other equipment -vehicular and equipment accidents (overturning, fall from heights, etc.)	-Adopt and implement the safest methods/ technology. -Ensure that persons doing specialized tasks (eg. Tree felling) are fully trained. – Use of well-maintained equipment. -Ensure use of personal protection gears

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
c. Laying Out	-fall from heights; being struck by vehicles and earth moving equipment -vehicular and earth moving equipment accidents -electrocution	-Use of well-maintained and suitable equipment and vehicles. -Use of properly trained crew and operators, especially drivers of large equipment like cranes and earth moving vehicles.
2. Open Pit Mining Operation		
a. Drilling and Excavation	-fall from the edge of a bench -being struck by falling rocks/debris at the foot of a face -inhalation of and contact with dusts which predisposes to respiratory diseases -Harmful noise levels -Being struck by a moving part of the drilling equipment	-Use of well-maintained and suitable equipment and vehicles. -Use of properly trained crew and operators, especially drivers of large equipment like cranes and earth moving vehicles.
b. Ore Extraction	-inhalation of and contact with dusts, nickel and other toxic heavy metals which could predispose to respiratory and skin diseases and heavy metal-induced diseases.	-Ensure use of appropriate personal protection equipment. -Use of appropriate equipment and vehicles with protective operator cabin.

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
c. Loading	-Being struck by falling rocks from loading arm -falls while gaining access to operator's cabin -vehicular accidents	-Ensure that drivers are well-trained. -Ensure use of appropriate and properly maintained vehichles and equipment. -Ensure implementation of safety protocols.
3. Transport of Ores and Overburden	Vehicular accidents (fall from edge of bench, collision with other vehicles or structures, overturning, etc.) -inhalation of and/or contact with dusts -high level noise	-Avoid operation during inclement weather. -Maintain proper security and cordon off hazardous areas. -Ensure good maintenance and regular testing vehicles, especially of brakes. -Driver/operator cabs are protected from dusts and heat. -Restrict access to vehicles
4. Ore Stockpiling	-Inhalation of and contact with dusts and heavy metals could predispose to respiratory/skin/eye diseases and heavy metal-induced diseases.	-Provide workers and operators with personal protection equipment (e.g. masks, gloves, googles).
D. Natural Calamities Due to Extreme Climate Events		
1. Increased frequency, intensity and range of tropical cyclones	- flooding of low lying areas; rock and land slides; storm surges and tidal flooding	-Ensure regular review of the Project's ERPP to ensure its adequacy and effectiveness to respond to changing situations.

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
2. Increased intensity and frequency of rains during wet season (Sept. to Nov.)	-flooding of low lying areas; rock/ land slides; tidal flooding; increased soil erosion and loss of soil fertility	-Ensure strict implementation of and compliance with the safety and health program, especially the EPRP. - Ensure regular and timely inspections and monitoring of containment dikes, retaining walls, and other retaining structures. -Ensure that all personnel, workers and contractors are properly oriented of the EPRP and ensure the regular conduct of emergency drills for situations such as fires, tsunami, flooding and earthquakes. -Conduct seminars, workshops, and other education/ information campaigns on climate change, its impacts and appropriate responses to mitigate impacts (tailored to the specific condtion in the area).
3. Drier dry seasons (March to May) and increased ambient temperatures	-fire incidents; increased airborne dusts; drying of water reservoirs and sources; increased diseases (i.e. respiratory, skin diseases, heat strokes, dizzy spells other diseases linked with hot, dry seasons)	-Ensure the implementation of the rehabilitation and reforestation program of mined-out areas and other denuded areas. -Strictly implement fire prevention and control measures and protocols. -Ensure strict implementation of dust suppression measures. -provide personnel protective equipment to workers, especially dust masks, eye goggles.
E. Earthquakes and Tsunamis	-collapse of infrastructues and buildings; spillage of fuel and chemicals predisposing to fires and toxic events; land slides; tsunami	-Formulate and implement an earthquake and tsunami emergency response plan that includes the following: monitoring and warning system; system of communication within and outside the mine site; SOPs for all personnel, workers and contractors; and evacuation plan. -Conduct regular and timely orientation and drills of all personnel, workers, contractors, as well as nearby communities, on the

Hazard Classification/ Unit Operation	Major Hazards	Mitigating Measures
		earthquake/tsunami emergency response plan and procedures. -Ensure regular and timely inspections and monitoring of all buildings and infrastructures within the mine site. -Ensure proper zoning and location, as well as good engineering, of buildings and other infrastructures.

5.0 SOCIAL DEVELOPMENT PLAN AND IEC IMPLEMENTATION

Some of the solutions to community problems identified by the respondents such as employment, livelihood programs, capacity building, scholarship and educational assistance, access to clean water, health programs, solid wastes management program, values formation and other community needs shall be the core programs, projects and activities of the company once it operates.

The proponent can replicate and enhance the community programs that are currently being implemented by some mining companies operating in the area. The company shall ensure that programs, projects and activities that will be identified shall not duplicate what other mining companies are implementing or it shall be complementary, since majority of the project-impact barangays are recipient of community development program of some mining companies.

The programs, projects and activities (PPAs) that are generally implemented by the mining companies are focused on education, health, livelihood, other social related services, promotion of cultural activities and among others.

The education program covers scholarship to indigent college students, support to daycare centers, elementary and secondary schools by means of improvement of school infrastructures and facilities, academic and non-academic activities, promotion of alternative learning systems for out of school youth, provision of instructional materials and equipment, and among others.

The health education program covers support to the provision of basic medicines, support to barangay health workers, capacity building, improvement of facilities and equipment, disaster preparedness, nutrition and health awareness.

Concerns	Community Beneficiary	Community Member Responsible	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
Livelihood and Employment						
• Gender Responsive Sustainable Livelihood Program (Marginalized Sector: Women, Youth, Fisherfolks, Farmers, Senior Citizens, Physically Challenged Persons or Persons with Disabilities) • Employment Program: Job Fairs • Skills training program: to give local residents of impact barangays the chance to qualify and compete for available employment opportunities during the implementation of the project or in other areas	• Interested Community Residents – Marginalized Sector	• Barangay officials • Sectoral Organizations	• LGU Municipal Planning and Development Office • Impact Barangays • Municipal Social Worker Department (MSWD) • Municipal Public Employment Services Office • TESDA • Cooperative Development Authority • Local Department of Labor and Employment	• Community Relations Officer	• Pre-construction • Construction • Operation	• LGU / Westchinamin CSR Program
Health Services						

Concerns	Community Beneficiary	Community Member Responsible	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
• Strengthening of Community-Based Health Program • Capacity building of Barangay Health Workers • Disease awareness and prevention • Regular medical check-up	• Men, Women, Children, Youth, Senior Citizens, PWDs	• Barangay Officials • Municipal and Barangay Health Workers	• Municipal Health Office (MHO) • Barangay Health Center	• Community Relations Officer	• Pre-construction • Construction • Operation	• LGU /Westchinamin CSR Program
Education Assistance						
• Adopt-a-School Program • Includes development/ improvement of school facilities • Brigada Eskwela • Provision of scholarship to qualified students	• Elementary School • Students, Teachers	• Barangay Officials (specifically the Council Member for Education)	• Department of Education (DepEd)	• Community Relations Officer	• Pre-construction • Construction • Operation	• LGU / Westchinamin CSR Program

Concerns	Community Beneficiary	Community Member Responsible	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
• Capacity building of teachers						
Public Infrastructure, Environment, and Sanitation						
• Implementation of Solid Waste Management in compliance with Republic Act 9003 • Infrastructure Development (Cement Donation) for Physical Improvement of the area that will impact on economic development, sanitation and safety	• Barangay Residents	• Barangay Officials (specifically the Council Member for Environment)	• Municipal Environment and Natural Resources Office (ENRO) • Municipal Engineer's Office	• Community Relations Officer • Environmental Officer/Pollution Control Officer	• Pre-construction • Construction • Operation	• LGU / Westchinamin CSR Program
Road Safety and Protective Services						
• Support for the Peace and Order Program of the Barangay and Municipal LGU • Partnership in the implementation of Traffic Management Program	• Barangay/ Sitio Redsidents • Institutions	Barangay Officials Barangay Peace and Security Officers	• Municipal Police • Municipal Engineer's Office • Municipal Disaster Risk Reduction and Management Office	• Community Relations Officer Mine Environmental Protection and Enhancement	• Pre-construction • Construction • Operation	• LGU / Westchinamin CSR Program • Environmental Management Program

Concerns	Community Beneficiary	Community Member Responsible	Government Agency/ Non-government Agency and Services	Proponent	Indicative Timeline	Source of Fund
• Emergency Response/ Calamity Assistance				Officer / Pollution Control Officer Safety Officer		• Safety and Health Program
Socio-Cultural Activities						
• Provision of support/assistance to LGUs in the conduct of activities that strengthens the development of a sustainable community	• Barangay/ Sitio Residents	Barangay Officials	• MSWDO • MPDO	• Community Relations Officer	• Pre-construction • Construction • Operation	• LGU / Westchinamin CSR Program

5.1 ***Information and Education Campaign***

Implementation of an intensive and consistent IEC Plan is the key to build a positive rapport with the host barangay and municipality. Previously implemented IEC activities were part of the SDMP. With the discussed policy changes, the IEC activities to be implemented by WestChinaMin Corp. will be part of the continuous community relations work of the plant to strengthen its relationship with the host community parallel to the implementation of the SDMP P/P/As.

Collected information from the community signifies the need to strengthen the IEC implementation of WestChinaMin Corp. A more regular, consistent, and accessible line of communication will be established between WestChinaMin Corp. and the host barangay. The approach will be two-way, that will ensure feedback mechanism in every communication activity. An open line of communication will be institutionalized that ensures the accessibility of bringing community concerns to the attention of the company. WestChinaMin Corp. on its part, will communicate all efforts and actions in addressing community concerns, intervention to avoid or mitigate negative impacts of the operations. The monthly IEC activity conducted by the Environment Team will be continued and to be strengthened by including the Safety and Health Team and most especially the Community Relations Team.

Table 157 - IEC Plan

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to the Project	IEC Schemes/ Strategy/ Methods	Information Medium	Indicative Timeline and Frequency	Indicative Cost
▪ Barangay Council and Sangguniang Bayan ▪ Local Non-Government/ Community Organizations ▪ Relevant National/ Regional Government Agencies	▪ Approval of the ECC Amendments and stipulated conditions ▪ Project description (i.e. project components, size/coverage ▪ Environmental Performance Report and Management Plan ▪ Concerns on the daily operations of WestChinaMin	▪ Intensive information dissemination on the approved ECC and EPRMP ▪ Consultation-Meetings	▪ Reproduction and Distribution of the approved ECC and EPRMP to the concerned LGUs ▪ Print materials: Brochure about the approved expansions ▪ Audio-Visual Presentations ▪ Two-way verbal communication and action report	▪ Prior to construction and installation of the processing plant	▪ Cost of printing the IEC materials ▪ Cost of holding consultation meetings
▪ Barangay Council and Sangguniang Bayan ▪ Local Non-Government/	▪ Presentation of project activities in relation to the construction and operation of the	▪ Printed information about the project updates and posting at impact barangays bulletin	▪ Print Materials: Posters or project bulletin ▪ Audio-Visual Presentations	▪ During construction and operation of the mining and plant facility	▪ Cost of printing the IEC materials ▪ Cost of holding consultation meetings

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to the Project	IEC Schemes/ Strategy/ Methods	Information Medium	Indicative Timeline and Frequency	Indicative Cost
Community Organizations	mining and plant facility ▪ Discussion on predicted impact and mitigation plan ▪ Gathering of community issues and concerns on the construction and operation of the mining and plant facility ▪ Reporting of results of project monitoring	board or information centers ▪ Consultation-meetings	▪ Two-way verbal communication and action report		
▪ Barangay Council and Sangguniang Bayan ▪ Local Non-Government/ Community Organizations	▪ Presentation of project activities in relation to the operations ▪ Gathering of community issues and concerns on	▪ Printed information about the project updates and posting at impact barangays bulletin board or information centers	▪ Print Materials: Posters/ project bulletin/ newsletter ▪ Audio-Visual Presentations	▪ During operations	▪ Cost of printing the IEC materials ▪ Cost of holding consultation meetings

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to the Project	IEC Schemes/ Strategy/ Methods	Information Medium	Indicative Timeline and Frequency	Indicative Cost
	the on-going operations ▪ Dissemination of the Corporate Social Responsibility Programs, possible partnership for the implementation and reporting of accomplishments ▪ Dissemination of program implementation and accomplishment on the Environmental Management Plan ▪ Dissemination of program implementation and accomplishment of	▪ Consultation-meetings	▪ Two-way verbal communication and action report		

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to the Project	IEC Schemes/ Strategy/ Methods	Information Medium	Indicative Timeline and Frequency	Indicative Cost
	Occupational Safety and Health ▪ Quarterly reporting of results MMT monitoring				
▪ Barangay Council and Sangguniang Bayan ▪ Local Non-Government/ Community Organizations ▪ Relevant National/ Regional Government Agencies	▪ Presentation decommissioning and closure plan ▪ Provision of updates on the decommissioning and closure activities ▪ Gathering of community issues and concerns on the decommissioning and closure activities ▪ Reporting of updates on the	▪ Printed information about the project updates and posting at impact barangays bulletin board or information centers ▪ Consultation-meetings	▪ Print Materials: Posters/ project bulletin/ newsletter ▪ Audio-Visual Presentations ▪ Two-way verbal communication and action report	▪ During Decommissioning and Closure Phase	▪ Cost of printing the IEC materials ▪ Cost of holding consultation meetings

Target Sector Identified as Needing Project IEC	Major Topics of Concern in Relation to the Project	IEC Schemes/ Strategy/ Methods	Information Medium	Indicative Timeline and Frequency	Indicative Cost
	monitoring of decommissioning and closure activities				

6.0 ENVIRONMENTAL COMPLIANCE MONITORING

6.1 Environmental Compliance

The company strictly implements and complies with the conditions specified in the issued ECC, the succeeding tables summarize the company's ECC compliance:

Table 158 - Summary Status of ECC & EMP Compliance

Condition / Requirement / Commitment	Compliance Status & Summary of Actions taken	Recommendation/Commitment for the next reporting
Compliance with ECC	**Complied**	**Continuous monitoring on compliance to ECC conditions**
Compliance with EMP **Pre-construction Phase**	**Land**: Terrestrial Biology ● Road tracing of previous logging road are disturbed in preparation for extensive drilling activities and possible identification of Temporary Facility location continuation of 2017 Work Program and Budget; ● Establishment of Nursery was carried-out that will support the vegetation and seedling requirements of all replanting works including soil stabilization works that use vegetation as materials ● Tree assessment were conducted of all obstructing trees for the proposed operation **People**: Employment ● Give priority to local residents ● Posting of vacancies and priority hiring of local and qualified individuals ● Coordination with the host and nearby barangay	Continuous monitoring and compliance to the provisions of RA 6969, RA 8749, RA 9275, RA 9003 and their respective IRR
Implementation of appropriate & effective environmental impact remedial actions in case of exceedances	**NO OPERATION for Year 2018** The Contingency Plan and Emergency Response Program is properly and strictly implemented in case of exceedances to DENR standards	Continuous monitoring and compliance to the provisions of RA 8749, RA 9275, RA 9003 and RA 6969 and their respective IRR
Complaints Management	No complaints were received since the company adheres to all laws,	In case of any complaints received, the company shall submit the

Condition / Requirement / Commitment	Compliance Status & Summary of Actions taken	Recommendation/Commitment for the next reporting
	rules and regulation set forth by all government agencies.	results of the settlement or resolution undertaken by the company
Realistic and sufficient budget for conducting the environmental monitoring and audit activities	WC allotted Php100,000.00 for the periodic sampling analysis (water, soil, air, etc.) where the Environmental Unit / PCO is in-charge to handle compliance to DENR Standards.	Cost summary of budgetary requirements and progress report shall be submitted
Accountability - qualified personnel are in-charged with the routine monitoring of the project activities in terms of education, training, knowledge and experience of the environmental team	MEPEO will also act as the PCO to lead and handle an Environmental Team.	The PCO will conduct a series of environmental orientation to all employees to become aware and familiar with it. If possible will invite EMB personnel to facilitate such orientation seminar.

Table 159 - Summary Status of Environmental Impact Management and Monitoring Plan Implementation

Monitoring Objective	Env'l Aspect	Envt'l Impact	Monitoring Parameter	Sampling & Measurement			Std. / EIS Prediction	Envt'l Management Measure	Remarks (EQPL)
				Location	Result				
					Previous	Current			
RA 8749 (Air Quality)	Dust Emission due to rehabilitation of old logging road	- Air & Noise pollution	TSP PM_{10}	At the starting point near the community and at the middle	None	None	TSP - 90µg/std PM_{10} – 60µg/std m3	Regular sprinkling of water during the rehabilitation of old logging road	Standard
RA 9003 (Solid Waste)	Generation of solid / residual waste	Land contamination; aesthetic impacts; spread of diseases	Proper waste management and disposal	Within the project area and camp site	None	Disposal of 80-100 kilograms/month of solid waste	Compliance to RA 9003 IRR	Provide color coded garbage bins for waste segregation	Standard
1978 NPCC	Noise generation	Sleep disturbance annoyance	Noise Levels	Camp sites; Nearest community, if visual inspection indicates possible noise disturbance	None	None	55 dB 50 dB 45 dB during Daytime, Morning to Evening and Nighttime	Strict implementation of daytime work schedule in order not to cause nuisance	Standard
DAO-2012-02 / FMB	Clearing of vegetation / Tree cutting	Disturbance of flora and fauna	Number of Trees Cut	Within the project area	None	None	Uniform replacement ratio for cut or relocated trees	Recommend balling of trees instead of cutting. Progressive	Standard

Monitoring Objective	Env'l Aspect	Envt'l Impact	Monitoring Parameter	Sampling & Measurement			Std. / EIS Prediction	Envt'l Management Measure	Remarks (EQPL)
				Location	Result				
					Previous	Current			
								rehabilitation as stated in EPEP	
DOLE / People	Employment	The activity will generate short term employment	Numbers hired	Within the project area	15	25	Local hiring		Standard

6.2 Environmental Monitoring Plan

This section presents the proposed framework for compliance monitoring of the project, which includes, among others, the environmental parameters necessary to monitor the identified key environmental impacts of the proposed project expansion.

As required by DENR Memorandum Circular No. 2010-14 and RPM for DAO 2003-30, and as a pro-active tool in minimizing/eliminating adverse project consequences to the environment, an "Environmental Quality Performance Level" (EQPL) has been identified for each critical parameter associated with identified significant project impacts. The limit level shall be the regulated threshold of pollutant (standard that must not be exceeded) while the action level is set lower than the limit level wherein management measures must be implemented so as not to reach the regulated threshold.

The following mechanisms and monitoring schemes are also discussed:

- Environmental Monitoring Plan;
- Multi-sectoral Monitoring Framework; and
- Environmental Guarantee and Monitoring Fund Commitment.

The new Environmental Monitoring Plan does not consider the EMOP in the old EPRMP since the provisions stated in the said report is very general. Specific monitoring plan per aspect were not presented, thus, a specific EMOP covering the current and the proposed operation was formulated.

The EQPLs presented below for the Environmental Monitoring Plan is only applicable for Effluent and Emissions regulations. The EQPLs were initially assigned the following values:

- Limit → DENR standard value
- Alert → 70% of the limit.
- Action →80% of the limit

The salient point of the said table is that Alert and Action EQPLs were only assigned to parameters that can be controlled by the project during construction and operation phases.

Table 160 - Environmental Monitoring Plan

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
CONSTRUCTION													
Soil	change in the landform and topography to the areas to be occupied by the mine infrastructures and proposed surface mining sites	▫ Volume of top soil removed/stockpiled	Random Sampling of Stock piled topsoil for flora and fauna survival trials	Quarterly	WESTCHINAMIN Parcels 1, 7, 2 and 8	WESTCHINAMIN MMT, DENR	Part of Admin. cost	▫	▫	▫	▫	▫	▫
	• Loss of top soil due to ground/site preparation activities	Area and Volume of top soil, removed/stockpiled. Number of trees felled ▫	Area measurement by the Length and Width method, Random Sampling. 100% inventory of trees felled	Quarterly	WESTCHINAMIN Mine site/ Processing Plant site	DENR, CENRO WESTCHINAMIN, MMT	• Loss of top soil due to ground/site preparation activities		▫	▫			
Water Quantity	Groundwater Surface water	▫ Deepwell pump operating time ▫ Volume of water extracted ▫ Rate of extraction	Flow meter	Daily monitoring Monthly reporting to NWRB or as required	Deepwell/s to be installed Rivers/Creeks which will be used as water source	Pollution Control Officer / Mining/Processing Operations	Part of operating cost	▫ 80& of the limit value	▫ 90% of the limit value	▫ Pumping rate limit set by the NWRB in the water permit	▫ Check any additional water uses	▫ Check any additional water uses, ▫ Check the water system for any leakages, ▫ Review the Water Management Plan	▫ Check any additional water uses, ▫ Check the water system for any leakages, ▫ Review the Water Management Plan ▫ Consider other alternative sources of water
Water Quality	Effluent Class C	▫ pH ▫ Temperature ▫ TSS ▫ COD ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Nitrate ▫ Sulfate ▫ Oil and Grease	In-situ measurement using hand-held water quality tester (pH, DO, temperature)	Monthly	Sedimentation Ponds at the mining area	Pollution Control Officer	Part of operating cost	<u>Class C</u> Fecal Coliforms: 320-359 MPN/100ml TSS=80-89 mg/l pH: 6.4-6.8 or 9.0-9.2 O&G= 4 - 4.4 mg/l As = 0.032-0.035 mg/l Cd = 0.008-0.0089 mg/l Pb = 0.08-0.089 mg/l	<u>Class C</u> Fecal Coliforms: 360-399 MPN/100ml TSS=90-99 mg/l pH: 6.1-6.3 or 9.3-9.4 O&G= 4.5 – 4.9 mg/l As = 0.036-0.039 mg/l Cd = 0.009-0.0099 mg/l Pb = 0.09-0.099 mg/l Hg = 0.0036-0.0039 mg/l	<u>Class C</u> Fecal Coliforms=400 MPN/100ml TSS=100 mg/l pH: 6.0 (min) or 9.5 (max) O&G=5 mg/l As = 0.04 mg/l Cd = 0.01 mg/l Pb = 0.1 mg/l Hg = 0.004 mg/l	▫ Investigate the source and identify possible pollutant sources ▫ Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources ▫ If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ Provide additional mitigation measures or pollution control facilities ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation
		▫ Color ▫ pH ▫ TSS ▫ Ammonia ▫ Nitrate ▫ Ni, Cd, Hg, Pb ▫ Oil &Grease ▫ Benzo(a)pyrene ▫ Surfactants	Grab sampling and laboratory analysis	Monthly	Oil and Water Separator discharge outlet Motorpool/shop	Pollution Control Officer	Part of operating cost						

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
		▫ BOD ▫ Fecal Coliform ▫ Ammonia ▫ Nitrate ▫ Phosphate ▫ Oil and Grease ▫ Surfactants		Monthly	Sewage Treatment Plant	Pollution Control Officer	Part of operating cost	Hg = 0.0032-0.0035 mg/l Ni = 0.8-0.89 mg/l Mn = 1.6-1.79 mg/l Nitrate = 11-12.5 mg/l Sulfate = 440-494 mg/l COD=80-89 mg/l Color=120-134 TCU Ammonia=0.4-0.44 mg/l Benzo(a)pyrene=2.4-2.6 µg/l Surfactants= 12-13.4 mg/l Phenol & Phenolic Substances =0.4-0.44 mg/l	Ni = 0.9-0.99 mg/l Mn = 1.8-1.99 mg/l Nitrate = 12.6-13.9 mg/l Sulfate = 495-549 mg/l COD=90-99 mg/l Color=135-149 TCU Ammonia=0.45-0.49 mg/l Benzo(a)pyrene=2.7-2.9 µg/l Surfactants= 13.5-14.9 mg/l Phenol & Phenolic Substances =0.45-0.49 mg/l	Ni = 1 mg/l Mn = 2 mg/l Nitrate = 14 mg/l Sulfate = 550 mg/l COD=100 mg/l Color=150 TCU Ammonia=0.5 mg/l Benzo(a)pyrene=3 µg/l Surfactants= 15 mg/l Phenol & Phenolic Substances =0.5 mg/l			and coordination with LGU
		▫ Temperature ▫ pH ▫ COD ▫ TSS ▫ Ammonia ▫ Nitrate ▫ Sulfate ▫ Chloride ▫ Fe, As, Cd, Hg, Pb ▫ Oil and Grease ▫ Phenol and Phenolic Substances		Monthly	Ferro-Nickel Processing Plant wastewater discharge	Pollution Control Officer	Part of operating cost						
Water Quality	Freshwater / Surface Water (Ambient)	▫ pH ▫ Temperature ▫ DO	In-situ measurement using hand-held water quality tester	Monthly	Class C: P2-C, P2-D, P2-E, P2-F, P2-G, P7-A, P7-B, P7-C Class B: P8-A, P8-C	Pollution Control Officer	Part of operating cost	Class C DO: 5.6-6.0 mg/l Fecal Coliforms: 160-179 MPN/100ml TSS: 64-72 mg/l pH: 7.1-7.4 or 8.8-8.85 O&G: 1.5-1.7 mg/l As:0.015-0.017 mg/l Cd:0.004-0.0044 mg/l Pb:0.04-0.044 mg/l Hg:0.0006-0.0079 mg/l Ni: 0.12-0.16 mg/l Mn: 0.12-0.16 mg/l Nitrate: 4-5.5 mg/l	Class C DO: 5.1-5.5 mg/l Fecal Coliforms: 180-199 MPN/100ml TSS: 73-79 mg/l pH: 6.6-7.0 or 8.86-8.9 O&G: 1.8-1.9 mg/l As:0.018-0.019 mg/l Cd: 0.0045-0.0049 mg/l Pb:0.045-0.049 mg/l Hg:0.0008-0.0009 mg/l Ni: 0.17-0.19 mg/l Mn: 0.17-0.19 mg/l Nitrate:5.6-6.9 mg/l Sulfate: 245-274 mg/l	Class C DO=5 mg/l minimum Fecal Coliforms=200 MPN/100ml TSS=80 mg/l pH: 6.5 or 9.0 O&G=2 mg/l As = 0.02 mg/l Cd = 0.005 mg/l Pb = 0.05 mg/l Hg = 0.001 mg/l Ni = 0.2 mg/l Mn = 0.2 mg/l Nitrate = 7 mg/l Sulfate = 275 mg/l	▫ Investigate the source and identify possible pollutant sources ▫ Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources ▫ If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ Provide additional mitigation measures or pollution control facilities ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
		▫ TSS ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Nitrate ▫ Sulfate ▫ Oil & Grease	Grab sampling and laboratory analysis										

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
								Sulfate: 220-244 mg/l					
Water Quality	Marine (Ambient)	▫ pH ▫ Temperature ▫ DO ▫ TSS ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Oil & Grease ▫ Nitrate ▫ Sulfate ▫ Fecal Coliforms	In-situ measurement using hand-held water quality tester Grab sampling and laboratory analysis	Quarterly	Class SC: MW1, MW2, MW3, MW4	Pollution Control Officer	Part of operating cost	Class SC DO: 5.6-6.0 mg/l Fecal Coliforms: 160-179 MPN/100ml TSS: 64-72 mg/l pH: 7.0-7.3 or 8.1-8.2 O&G: 2.4-2.6 mg/l As:0.015-0.017 mg/l Cd:0.004-0.0044 mg/l Pb:0.04-0.044 mg/l Hg:0.0016-0.0018 mg/l Ni:0.048-0.053 mg/l Mn:0.30-0.35 mg/l Nitrate: 8.0-8.9 mg/l Sulfate: 220-244 mg/l	Class SC DO: 5.1-5.5 mg/l Fecal Coliforms: 180-199 MPN/100ml TSS: 73-79 mg/l pH: 6.6-7.0 or 8.3-8.4 O&G: 2.7-2.9 mg/l As:0.018-0.019 mg/l Cd: 0.0045-0.0049 mg/l Pb:0.045-0.049 mg/l Hg:0.0018-0.0019 mg/l Ni:0.054-0.059 mg/l Mn:0.36-0.39 mg/l Nitrate:9.0-9.9 mg/l Sulfate: 245-274 mg/l	Class SC DO=5 mg/l minimum Fecal Coliforms=200 MPN/100ml TSS=80 mg/l pH: 6.5 or 8.5 O&G=3 mg/l As = 0.02 mg/l Cd = 0.005 mg/l Pb = 0.05 mg/l Hg = 0.002 mg/l Ni = 0.06 mg/l Mn = 0.4 mg/l Nitrate = 10 mg/l Sulfate = 275 mg/l	▫ Investigate the source and identify possible pollutant sources ▫ Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources ▫ If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ Provide additional mitigation measures or pollution control facilities ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
Water Quality	Groundwater	▫ pH ▫ Temperature ▫ Conductivity ▫ TDS ▫ TSS ▫ Oil &Grease ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Nitrate ▫ Chloride ▫ Fecal Coliforms ▫ Sulfate	In-situ measurement using hand-held water quality tester Grab sampling and laboratory analysis	Monthly	Deepwell/s to be installed GW1 and GW2	Pollution Control Officer	Part of operating cost	Class A TSS: 30-39 mg/l pH: 7.0-7.3 or 8.1-8.2 O&G: 0.8-0.85 mg/l Chloride:150-119 mg/l As:0.008-0.0085 mg/l Cd:0.0018-0.0023 mg/l Pb:0.006-0.0079 mg/l Hg:0.0006-0.0079 mg/l Ni:0.012-0.015 mg/l Mn:0.12-0.16 mg/l	Class A TSS: 40-49 mg/l pH: 6.6-7.0 or 8.3-8.4 O&G: 0.86-0.9 mg/l Chloride:200-249 mg/l As:0.0086-0.009 mg/l Cd: 0.0024-0.0029 Pb:0.008-0.009 mg/l Hg:0.0008-0.0009 mg/l Ni:0.016-0.019 mg/l Mn:0.17-0.19 mg/l	Class A TSS=50 mg/l pH: 6.5 or 8.5 O&G=1 mg/l Chloride=250 mg/l As = 0.01 mg/l Cd = 0.003 mg/l Pb = 0.01 mg/l Hg = 0.001 mg/l Ni = 0.02 mg/l Mn = 0.2 mg/l	▫ Investigate the source and identify possible pollutant sources ▫ Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources ▫ ▫ If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ ▫ Provide additional mitigation measures or pollution control facilities ▫ ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
								Nitrate: 4-5.5 mg/l Fecal Coliforms >1.1 MPN/100ml Sulfate: 150-200 mg/l	Nitrate:5.6-6.9 mg/l Fecal Coliforms >1.1 MPN/100ml Sulfate:201-249 mg/l	Nitrate = 7 mg/l Fecal Coliforms <1.1 MPN/100ml Sulfate = 250 mg/l			
Hydrologic Hazards	Flooding / river overflow	▫ Date of occurrence ▫ Frequency in a year	Observation	As needed; Yearly summary	Rivers/creeks within the project area	Pollution Control Officer / Emergency Response Team	Part of operating cost	▫ n/a	▫ n/a	▫ n/a	▫ Continuous improvement of the Emergency Response Plan;	▫ Continuous improvement of the Emergency Response Plan; Stream stabilization ▫ Implementation of Progressive rehabiltation	▫ Continuous improvement of the Emergency Response Plan; ▫ Stream stabilization ▫ Implementation of Progressive rehabiltation
Environmental Aspect # 2: The Water – control of sedimentation and siltation in coastal waters and river system	Increased sedimentation in rivers and coastal waters through run-off and spillage into waterways draining into the sea	▫ Coastal water turbidity; sediment blanketing in corals, seagrass, reduced plankton diversity and abundance	Annual marine ecology monitoring employing consistent scientific methods in resource and habitat assessments (i.e., coral line intercept transects, fish visual census, plankton nets, etc**)**	Once a year	Consistent stations/same as baseline assessment	ChinaMin Environmental Officer/Marine ecology Consultant	PhP 1m	▫ Discernible blanketing of silt and sediments in corals compared to baseline findings and discoloration of seawater	50% decrease in baseline findings and discoloration of seawater and increase in HABs ▫	70% decrease in baseline findings on marine resources/species; discoloration of seawater; increase of HABs ▫	Conduct marine biota monitoring; ▫ Company to check if effluent released complies with DENR AO-35; check degree of escape of sediments in rivers and waterways draining into the sea and into Uacon lake	Increase frequency of conduct of marine biota monitoring to semi-annual; Company to check if effluent released complies with DENR AO-35; install additional control weirs and sediment ponds near rivers and waterways; ▫ Intensify re-vegetation and anti-erosion reinforcements	Increase the frequency of conduct of marine biota monitoring to Quarterly; Company to check if effluent released complies with DENR AO-35; Temporarily cease activities in point sources of sediments ▫
	Water pollution from domestic wastewater carried downstream and fugitive used oil of construction equipment and vehicles	▫ Coastal water quality – presence of pil residues and wastes	Periodic actual inspection	As necessary based on monitoring	Uacon lake and estuary; baseline stations	ChinaMin Environmental Officer/Marine ecology Consultant	Part of operating cost	▫ Discernible blanketing of waste material and oil in benthic substrate, corals compared to baseline findings and discoloration of seawater	Significant pollution in coastal waters - Discernible blanketing of waste material and oil in benthic substrate, corals	Enhanced pollution in coastal waters - Discernible blanketing of waste material and oil in benthic substrate, corals, seagrass and mangroves	Company to check if effluent released complies with DENR AO-35; check degree of escape of sediments in rivers and waterways draining into the sea and into Uacon lake	Increase frequency of conduct of marine biota monitoring to semi-annual; Company to check if effluent released complies with DENR AO-35; install additional waste control weirs and recovery measures near rivers and waterways; Reinforce waste management system and oil and grease recovery systems	Increase the frequency of conduct of marine biota monitoring to Quarterly; Company to check if effluent released complies with DENR AO-35; Temporarily cease activities in point sources of pollution
Water Component-control of sedimentation and siltation in coastal	Impacts on primary production in coastal waters	▫ Percent cover, diversity indices and relative abundance of phytoplankton, zooplankton,	Plankton community samplig	Semi-annual	Same as sampling stations in baseline studies	ChinaMin Environmental Officer/Marine ecology Consultant	Part of operating cost	▫ Significant reduction in plankton density and benthos composition	Significant reduction in plankton density and benthos composition	Extreme reduction in plankton density and benthos composition	Conduct marine biota monitoring; determine causes of plankton deterioration. Company to check if effluent released	Increase frequency of conduct of marine biota monitoring to semi-annual; Company to check if effluent	Increase the frequency of conduct of marine biota monitoring to Quarterly; Company to check if effluent released complies with DENR AO-35; reinforce

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
waters and river system (Marine Ecology)		bottom benthos, fish, corals, Seagrass									complies with DENR AO-35	released complies with DENR AO-35	sediment sequestration measures
Employment; taxes	People: Community benefits from the project	▫ Employment, Tax revenues to LGUs, community projects initiated by the proponent, other benefits of the community from the project	FGDs, KIIs, household survey (when necessary) examination of official record (e.g. revenue reports)	Annual	Project-affected barangays	Proponent thru MEPEO; MMT; 3rd party consultant							
OPERATION													
	▫Improper disposal of domestic wastes/processing plant waste materials may contaminate the soil ▫Soil Contamination due to accidental fuel and lubricant spills from vehicles and equipment may occur ▫Soil Contamination due to accidental spills coming prom the processing plant ▫Loss of soil quality	pH USEPA Standard (1993)	Direct measurement Random Sampling. Electrometric Flame AAS Flame AAS	Semi annual Annually Semi Annual	Assay Laboratory Motor pool area and processing plant storage facilities Haulers/contractors, Maintenance mechanic, MMT Processing Plant site	WESTCHINAMIN MMT, Pollution Control officer MMT, WESTCHINAMIN pollution Control officer MMT, WESTCHINAMIN		RA 9003 7.7 0.1 ppm 5.0 Ppm 9.0	Soil Quality Management plan 8.1 0.3 Ppm	RA 9003 6.5 – 8.5 1.0 Ppm	Conduct re- testing to verify	Conduct re- testing to verify	Conduct visit at the said sampling station and conduct retesting using a 3rd party DENR

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		Mercury (Hg) Copper (Cu Lead (Pb)	Flame AAS		Processing Plant site/Stockpile areas sampling stations	pollution Control officer/consultant MMT, WESTCHINAMIN pollution Control officer/consultant	Part of operation Cost	▫ ppm	6.0 Ppm 10.0 ppm	10.0 Ppm 20.0 ppm	1.Check operation of the Processing plant and possible sources 2.If the problem is within the processing plant, inform the plant manager to conduct trouble shooting/good house keeping.	1.Check operation of processing plant and possible sources 2. If the problem is within the treatment facility, inform unit manager to conduct trouble shooting/adjustments to ensure the parameters are within the allowable limit. · If source is not the site, inform MMT regarding possible source of contamination for the group investigation and coordination with the Lgu	accredited sampling firm to confirm · If source is not the site, inform MMT regarding possible source for the group investigation and coordination with the LGU ·Coordinate with the Operations/ Utilities and Engineering/Envi. Officer regarding the matter
Water Quantity	Groundwater Surface water	▫ Deepwell pump operating time ▫ Volume of water extracted ▫ Rate of extraction	Flow meter	Daily monitoring Monthly reporting to NWRB or as required	Deepwell/s to be installed Rivers/Creeks which will be used as water source	Pollution Control Officer / Mining/Processing Operations	Part of operating cost	▫ 80& of the limit value	90% of the limit value	Pumping rate limit set by the NWRB in the water permit	Check any additional water uses	▫ Check any additional water uses, ▫ Check the water system for any leakages, ▫ Review the Water Management Plan	▫ Check any additional water uses, ▫ Check the water system for any leakages, ▫ Review the Water Management Plan ▫ Consider other alternative sources of water
Water Quality	Effluent Class C	▫ pH ▫ Temperature ▫ TSS ▫ COD ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Nitrate ▫ Sulfate ▫ Oil and Grease	In-situ measurement using hand-held water quality tester (pH, DO, temperature) Grab sampling and laboratory analysis	Monthly	Sedimentation Ponds at the mining area	Pollution Control Officer	Part of operating cost	Class C Fecal Coliforms: 320-359 MPN/100ml TSS=80-89 mg/l pH: 6.4-6.8 or 9.0-9.2 O&G= 4 - 4.4 mg/l As = 0.032-0.035 mg/l Cd = 0.008-0.0089 mg/l Pb = 0.08-0.089 mg/l Hg = 0.0032-0.0035 mg/l Ni = 0.8-0.89 mg/l	Class C Fecal Coliforms: 360-399 MPN/100ml TSS=90-99 mg/l pH: 6.1-6.3 or 9.3-9.4 O&G= 4.5 – 4.9 mg/l As = 0.036-0.039 mg/l Cd = 0.009-0.0099 mg/l Pb = 0.09-0.099 mg/l Hg = 0.0036-0.0039 mg/l Ni = 0.9-0.99 mg/l Mn = 1.8-1.99 mg/l	Class C Fecal Coliforms=400 MPN/100ml TSS=100 mg/l pH: 6.0 (min) or 9.5 (max) O&G=5 mg/l As = 0.04 mg/l Cd = 0.01 mg/l Pb = 0.1 mg/l Hg = 0.004 mg/l Ni = 1 mg/l Mn = 2 mg/l	▫ Investigate the source and identify possible pollutant sources Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ Provide additional mitigation measures or pollution control facilities If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
		▫ Color ▫ pH ▫ TSS ▫ Ammonia ▫ Nitrate ▫ Ni, Cd, Hg, Pb ▫ Oil &Grease ▫ Benzo(a)pyrene ▫ Surfactants		Monthly	Oil and Water Separator discharge outlet Motorpool/shop	Pollution Control Officer	Part of operating cost						
		▫ BOD ▫ Fecal Coliform ▫ Ammonia ▫ Nitrate		Monthly	Sewage Treatment Plant	Pollution Control Officer	Part of operating cost						

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
		▫ Phosphate ▫ Oil and Grease ▫ Surfactants						Mn = 1.6-1.79 mg/l Nitrate = 11-12.5 mg/l Sulfate = 440-494 mg/l COD=80-89 mg/l Color=120-134 TCU Ammonia=0.4-0.44 mg/l Benzo(a)pyrene=2.4-2.6 µg/l Surfactants= 12-13.4 mg/l Phenol & Phenolic Substances =0.4-0.44 mg/	Nitrate = 12.6-13.9 mg/l Sulfate = 495-549 mg/l COD=90-99 mg/l Color=135-149 TCU Ammonia=0.45-0.49 mg/l Benzo(a)pyrene=2.7-2.9 µg/l Surfactants= 13.5-14.9 mg/l Phenol & Phenolic Substances =0.45-0.49 mg/l	Nitrate = 14 mg/l Sulfate = 550 mg/l COD=100 mg/l Color=150 TCU Ammonia=0.5 mg/l Benzo(a)pyrene=3 µg/l Surfactants= 15 mg/l Phenol & Phenolic Substances =0.5 mg/l			
		▫ Temperature ▫ pH ▫ COD ▫ TSS ▫ Ammonia ▫ Nitrate ▫ Sulfate ▫ Chloride ▫ Fe, As, Cd, Hg, Pb ▫ Oil and Grease ▫ Phenol and Phenolic Substances		Monthly	Ferro-Nickel Processing Plant wastewater discharge	Pollution Control Officer	Part of operating cost						
Water Quality	Freshwater / Surface Water (Ambient)	▫ pH ▫ Temperature ▫ DO	In-situ measurement using hand-held water quality tester	Monthly	Class C: P2-C, P2-D, P2-E, P2-F, P2-G, P7-A, P7-B, P7-C Class B: P8-A, P8-C	Pollution Control Officer	Part of operating cost	Class C DO: 5.6-6.0 mg/l Fecal Coliforms: 160-179 MPN/100ml TSS: 64-72 mg/l pH: 7.1-7.4 or 8.8-8.85 O&G: 1.5-1.7 mg/l As:0.015-0.017 mg/l Cd:0.004-0.0044 mg/l Pb:0.04-0.044 mg/l Hg:0.0006-0.0079 mg/l Ni: 0.12-0.16 mg/l Mn: 0.12-0.16 mg/l Nitrate: 4-5.5 mg/l Sulfate: 220-244 mg/l ▫	Class C DO: 5.1-5.5 mg/l Fecal Coliforms: 180-199 MPN/100ml TSS: 73-79 mg/l pH: 6.6-7.0 or 8.86-8.9 O&G: 1.8-1.9 mg/l As:0.018-0.019 mg/l Cd: 0.0045-0.0049 mg/l Pb:0.045-0.049 mg/l Hg:0.0008-0.0009 mg/l Ni: 0.17-0.19 mg/l Mn: 0.17-0.19 mg/l Nitrate:5.6-6.9 mg/l Sulfate: 245-274 mg/l	Class C DO=5 mg/l minimum Fecal Coliforms=200 MPN/100ml TSS=80 mg/l pH: 6.5 or 9.0 O&G=2 mg/l As = 0.02 mg/l Cd = 0.005 mg/l Pb = 0.05 mg/l Hg = 0.001 mg/l Ni = 0.2 mg/l Mn = 0.2 mg/l Nitrate = 7 mg/l Sulfate = 275 mg/l	▫ Investigate the source and identify possible pollutant sources Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ Provide additional mitigation measures or pollution control facilities If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
		▫ TSS ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Nitrate ▫ Sulfate ▫ Oil & Grease ▫	Grab sampling and laboratory analysis										
Water Quality	Marine	▫ pH ▫ Temperature ▫ DO	In-situ measurement using hand-held								▫	▫	▫

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
	(Ambient)		water quality tester										
		▫ TSS ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Oil & Grease ▫ Nitrate ▫ Sulfate ▫ Fecal Coliforms	Grab sampling and laboratory analysis	Quarterly	Class SC: MW1, MW2, MW3, MW4	Pollution Control Officer	Part of operating cost	Class SC DO: 5.6-6.0 mg/l Fecal Coliforms: 160-179 MPN/100ml TSS: 64-72 mg/l pH: 7.0-7.3 or 8.1-8.2 O&G: 2.4-2.6 mg/l As:0.015-0.017 mg/l Cd:0.004-0.0044 mg/l Pb:0.04-0.044 mg/l Hg:0.0016-0.0018 mg/l Ni:0.048-0.053 mg/l Mn:0.30-0.35 mg/l Nitrate: 8.0-8.9 mg/l Sulfate: 220-244 mg/l	Class SC DO: 5.1-5.5 mg/l Fecal Coliforms: 180-199 MPN/100ml TSS: 73-79 mg/l pH: 6.6-7.0 or 8.3-8.4 O&G: 2.7-2.9 mg/l As:0.018-0.019 mg/l Cd: 0.0045-0.0049 mg/l Pb:0.045-0.049 mg/l Hg:0.0018-0.0019 mg/l Ni:0.054-0.059 mg/l Mn:0.36-0.39 mg/l Nitrate:9.0-9.9 mg/l Sulfate: 245-274 mg/l	Class SC DO=5 mg/l minimum Fecal Coliforms=200 MPN/100ml TSS=80 mg/l pH: 6.5 or 8.5 O&G=3 mg/l As = 0.02 mg/l Cd = 0.005 mg/l Pb = 0.05 mg/l Hg = 0.002 mg/l Ni = 0.06 mg/l Mn = 0.4 mg/l Nitrate = 10 mg/l Sulfate = 275 mg/l	▫ Investigate the source and identify possible pollutant sources ▫ Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources ▫ If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ Provide additional mitigation measures or pollution control facilities ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
Water Quality	Groundwater	▫ pH ▫ Temperature ▫ Conductivity ▫ TDS	In-situ measurement using hand-held water quality tester	Monthly	Deepwell/s to be installed GW1 and GW2	Pollution Control Officer	Part of operating cost	Class A TSS: 30-39 mg/l pH: 7.0-7.3 or 8.1-8.2 O&G: 0.8-0.85 mg/l Chloride:150-119 mg/l As:0.008-0.0085 mg/l Cd:0.0018-0.0023 mg/l Pb:0.006-0.0079 mg/l Hg:0.0006-0.0079 mg/l Ni:0.012-0.015 mg/l Mn:0.12-0.16 mg/l	Class A TSS: 40-49 mg/l pH: 6.6-7.0 or 8.3-8.4 O&G: 0.86-0.9 mg/l Chloride:200-249 mg/l As:0.0086-0.009 mg/l Cd: 0.0024-0.0029 Pb:0.008-0.009 mg/l Hg:0.0008-0.0009 mg/l Ni:0.016-0.019 mg/l Mn:0.17-0.19 mg/l Nitrate:5.6-6.9 mg/l	Class A TSS=50 mg/l pH: 6.5 or 8.5 O&G=1 mg/l Chloride=250 mg/l As = 0.01 mg/l Cd = 0.003 mg/l Pb = 0.01 mg/l Hg = 0.001 mg/l Ni = 0.02 mg/l Mn = 0.2 mg/l Nitrate = 7 mg/l	▫ Investigate the source and identify possible pollutant sources ▫ Conduct corrective actions if needed	▫ Investigate the source to identify possible pollutant sources ▫ ▫ If the problem is within the construction/operation area, conduct adjustments/ appropriate corrective action at identified pollutant source.	▫ Investigate the source to identify possible pollutant sources ▫ ▫ Provide additional mitigation measures or pollution control facilities ▫ ▫ If source is not project construction, inform MMT regarding possible source for the group's investigation and coordination with LGU
		▫ TSS ▫ As, Cd, Pb, Hg, Ni, Mn ▫ Oil & Grease ▫ Nitrate ▫ Sulfate ▫ Fecal Coliforms	Grab sampling and laboratory analysis										

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
			Method	Frequency	Location			EQPL Range			Management Measure		
								Alert	Action	Limit	Alert	Action	Limit
								Nitrate: 4-5.5 mg/l Fecal Coliforms >1.1 MPN/100ml Sulfate: 150-200 mg/l	Fecal Coliforms >1.1 MPN/100ml Sulfate:201-249 mg/l	Fecal Coliforms <1.1 MPN/100ml Sulfate = 250 mg/l			
Water Component (deterioration of Marine Ecology parameters compared to baseline)	Negative impacts on marine ecology in coastal areas fronting the project site; reduction in marine ecology parameters compared to baseline	▫ Species composition, density and relative abundance of phytoplankton, zooplankton, bottom benthos, fish, corals, seagrass, seaweeds	Standard scientific methods used in baseline assessment- Line Transect Method Fish Visual Census, plankton/benthos sampling, mangrove and seagrass assessment; Key Informant Interview	Annual	Same stations during baseline study	ChinaMin Environmental Officer/Marine ecology Consultant	PhP 1m per year	30% decrease in baseline findings especially in live coral cover inside MPAs; discoloration of sea waters	50% decrease in baseline findings and discoloration of sea water; and increase in HABs	70% decrease in baseline findings and discoloration of sea water; and increase in HABs	▫ Conduct marine biota monitoring; company to check if effluent released complies with DAO 2016-08	▫ Increase the frequency of conduct of marine biota monitoring to semi-annual; Company to check if effluent released complies with DAO 2016-08	Increase the frequency of conduct of marine biota monitoring to Quarterly; Company to check if effluent released complies with DENR AO-35; Temporarily cease activities in point sources of pollution ▫
Marine ecology-marine pollution	Domestic wastewater pollution	▫ Deterioration of water quality; algal blooms	Water quality measurement and monitoring; plankton community sampling	Plankton net and diversity indices; assess harmful algal blooms (HABs)	Same plankton stations during baseline study	ChinaMin Environmental Officer/Marine ecology Consultant	PhP .5m per year	Increased marine pollution levels and HAB occurence	HAB contamination of bivalves and fish	HAB contamination of bivalves and fish and consequent health hazards	▫ Check efficiency of septic tanks and wastewater treatment and containment system	Check if effluent released complies with DENR AO-35; ▫ Improve wastewater treatment and recovery systems	Divert all wastewater into additional treatment and recovery ponds and structures Check if effluent released complies with DENR AO-35; Temporarily cease activities in point sources of pollution ▫
Mangrove and river ecology-sedimentation and siltation in coastal waters and river system	Alteration of mangrove habitats due to sedimentation and waste material	▫ Disruption in mangrove recruitment; loss of fish nursery and habitat	Periodic mangrove and river ecology monitoring	Standard methods	Same as baseline stations	ChinaMin Environmental Officer/Marine ecology Consultant	PhP .3m per year	Increased sediment accretions in mangrove areas and scouring of riverbanks near Uacon Lake	Increased sediment accretions in mangrove areas and scouring of riverbanks near Uacon Lake	Increased sediment accretions in mangrove areas and scouring of riverbanks near Uacon Lake	▫ Reinforce silt and sediment control measures especially near waterways; Intensify re-vegetation and anti-erosion reinforcements including riverbank rehabilitation and mangrove reforestation	Reinforce silt and sediment control measures especially near waterways; Intensify re-vegetation and anti-erosion reinforcements including riverbank rehabilitation and mangrove reforestation	Intensify silt and sediment control measures especially near waterways; Intensify re-vegetation and anti-erosion reinforcements including riverbank rehabilitation and mangrove reforestation
Employment, tax	Community benefits from the project	▫ Employment, Tax revenues to LGUs, community projects	FGDs, KIIs, household survey (when necessary) examination of	Semi-annual	Project affected barangays	Proponent thru MEPEO; MMT; 3rd party consultant					▫		

Module	Environmental Sector	Parameters to be monitored	Sampling and Measurement			Lead Person/ Office	Annual Estimated Cost (Php)	EQPL Management Scheme					
								EQPL Range			Management Measure		
			Method	Frequency	Location			Alert	Action	Limit	Alert	Action	Limit
		initiated by the proponent, other benefits of the community from the project	official record (e.g. revenue reports)										
ABANDONMENT													
Rehabilitation works	Land: Decrease in diversity and abundance Possible extirpation of species	Flora: Biodiversity indices, species richness and abundance Fauna: ▫ Biodiversity indices, species richness and abundance	Sampling and interviews Site observation and documentation Transect survey, mist netting and cage trapping	Duration is for 2 years after the cease of operation following a semi-annual monitoring pattern	Baseline sampling stations	Proponent thru MEPEO; MMT; 3rd party consultant	Part of FMRDP Cost				▫		
Removal / dismantling of unnecessary infrastructures	People: Safety issue, eyesore to landscape	▫ To be identified in the Final Mine Rehabilitation and Decommissioning Plan (FMRDP)	Based on methodology presented in the FMRDP	Once	Site location auxiliary facilities	Proponent thru MEPEO; MMT; 3rd party consultant	Part of FMRDP Cost				▫		
Disposal of solid wastes and hazardous materials	Water: Water quality The People: Health Hazard	▫ Based on the result of the Environmental Site Assessment (ESA) that will be conducted prior to abandonment	Based on the recommendation of the ESA that will be conducted prior to abandonment	Once	Project site	Proponent thru MEPEO; MMT; 3rd party consultant	Part of FMRDP Cost				▫		

1.1 Multi-sectoral Monitoring Framework

Multi-sectoral monitoring for the project shall be based on the guidelines/requirements of the Revised Procedural Manual for DENR Administrative Order 2003-30 (Implementing Rules and Regulations of Presidential Decree No. 1586, Establishing the Philippine Environmental Impact Statement System).

A Multi-partite Monitoring Team (MMT) was established to assess and validate compliance with the relevant environmental standards and shall be restructured base on on the new guidelines stated in DAO 2017 - 15. The new MMT will be composed by representatives of the following offices:

- Municipal Environment and and Natural Resources Officer (Chairman)
- Rural Health Unit
- Local Government Unit
- Non-Government Organization
- Locally recognized Community Leaders (maximum of two representatives)

The MMT shall have the following functions:

- Monitor, assess, and validate the project's compliance as stated in the EIA Report, ECC, and other relevant environmental standards
- Set-up project specific (location-based) environmental standards in accordance with environmental standards identified above
- Prepare members of the MMT to handle monitoring activities through proper trainings
- Management and disposition of complaints formally filed against the project proponent and its contractors
- Fiduciary management of funds allocated for the above purposes

As stated under the Philippine Environmental Impact Statement System (PEISS), MMTs are organized to encourage public participation, to promote greater stakeholder vigilance and to provide an appropriate check and balance mechanisms in the monitoring of project implementation. The MMT is recommendatory to EMB. MMTs have the primary responsibility of validation of Proponent's environmental performance, with the following specific functions:

i. Validate project compliance with the conditions stipulated in the ECC and the EMP;
ii. Validate Proponent's conduct of self-monitoring;

iii. Receive complaints, gather relevant information to facilitate determination of validity of complaints or concerns about the project and timely transmit to the Proponent and EMB recommended measures to address the complaint;

iv. Prepare, integrate and disseminate simplified validation reports to community stakeholders;

v. Make regular and timely submission of MMT Reports based on the EMB-prescribed format.

6.3 Contingent Liability and Rehabilitation

CLRF is an environmental guarantee fund mechanism to ensure just and timely compensation for damages and progressive and sustainable rehabilitation for any adverse effect a mining operation or activity may cause.

The CLRF shall be in the form of the Mine Rehabilitation Fund and the Mine Waste and Tailing Fess as stipulated in the Mining Act and shall be administered by the CLRF Steering Committee.

6.3.1 Mine Rehabilitation Fund (MRF)

A Mine Rehabilitation Fund (MRF) shall be established and maintained by proponent as a reasonable environmental deposit to ensure availability of funds for the satisfactory compliance with the commitments and performance of the activities stipulated in the EPEP/AEPEP during specific project phase.

The MRF shall be deposited as a Trust Fund in a Government depository bank and shall be used for physical and social rehabilitation of areas and communities effected by mining activities and for research on the social, technical and preventive aspects of rehabilitation.

The MRF shall be in two forms: Monitoring Trust Fund (MTF); and Rehabilitation Cash Fund (RCF).

6.3.1.1 Rehabilitation Cash Fund (RCF)

The Contractor/Permit Holder shall set up an RCF for a designated amount to ensure compliance with the approved rehabilitation activities and schedules for specific mining project phase, including research programs as defined in the EPEP/AEPEP. It shall be equivalent to ten percent (10%) of the total amount needed to implement the EPEP or Five Million Pesos (P5,000,000.00), whichever is lower. It shall be deposited as a Trust Fund in a mutually agreed Government depository bank in four (4) equal quarterly deposits within fifteen (15) calendars days from the beginning of each quarter of the first year following the approval of the EPEP.

In the event of withdrawals from RCF, the Contractor shall annually replenish the RCF so as to maintain the minimum required amount.

6.4 Environmental Trust Fund (ETF)

ETF is guarantee instrument, which will be used to compensate aggrieved parties for any damages to life or property, undertake community-based environmental programs and conduct environmental research aimed at strengthening measures to prevent environmental damage and to finance restoration and rehabilitation of environmental quality caused by the project. This could be in the form of insurance, letters of credit, trust fund, other financial instruments and other similar guarantee instruments.

7.0 ABANDONMENT/DECOMMISSIONING/REHABILITATION AND GENERIC GUIDELINES

As with the end of every industry, the closure of the Project can affect the host community, create loss/decrease in taxes, loss of employment, income and/or business opportunities derived from the project.

The following objectives will be considered in the decommissioning plan:

a. Rehabilitate the disturbed areas to a condition that is beneficial to the environment and conforms to the land use plan of the municipality and/or province that is mutually concurred by the community, government agencies, and the company;
b. Manage and control off-site contamination by fortifying environmental control structures and implementation of appropriate rehabilitation methods;
c. Remove and disband unnecessary Project facilities and equipment used in the operation;
d. Conduct a comprehensive management and monitoring of rehabilitated areas until such time that the area is sustaining and is biologically and physically acceptable with the preferred final land-use; and
e. Monitor SDP implementations and implement post-capacity training on the alternative skills and livelihood opportunities that were initiated during the onset of the Project's operation.

7.1 Decommissioning Plan

To carry out the transitional stage between cessation of operation and actual closure, the company also plans to employ the following strategies:

Decommissioning Strategy	Timeframe
Mobilization of the Closure Team. Start of IEC Campaign as part of social preparation, and creation of Closure ComRel Plan.	Closure Planning. Three (3) years before closure
Inventory of all equipment and facilities by the Closure Team.	Part of Closure Planning Within two (2) years before Closure
Assessment of the conditions of equipment and facilities by the Closure Team.	Part of Closure Planning Within 2 years before Closure
Planning and review of decommissioning procedures vis-à-vis the standard operating procedures. Coordination with contractors.	Part of Closure Planning Within one (1) year before Closure
Cross matching of company personnel and residents with the decommissioning tasks. Trainings/seminars will be provided as the need arises. Consultation with stakeholders. Strengthening of IEC Campaign as part of social preparation.	Part of Closure Planning Within 1 year before Closure
Decommissioning of equipment and facilities.	Decommissioning and Rehabilitation Phase Within 6 months after closure
Post assessment by the Closure Team on the decommissioned equipment and facilities.	Decommissioning and Rehabilitation Phase Within and after 1 year of closure
Rehabilitation of the decommissioned project component.	Decommissioning and Rehabilitation Phase Within and after 2 year of closure

8.0 INSTITUTIONAL PLAN FOR EMP IMPLEMENTATION

The project organizational structure will be comprised mainly by the operations manager and department heads. The pollution control officer will report directly to the operations manager and shall take lead in implementing the environmental management programs as committed in the Impacts Management Plan (IMP) and the Environmental Monitoring Plan (EMoP) presented in this EPRMP.

The PCO/Environment Officer shall also have the following functions:

- Monitoring and evaluating the effectiveness of the mitigating and enhancement measures;
- Planning, proposing and implementing modifications or additional measures deemed necessary to effectively protect the environment;
- Implement environmental management including the ERP in partmership with the safety officer;
- Coordinate with relevant oversight agencies and other entities, including the local government units to ensure their effective participation in the MMT activities;
- Ensure compliance to ECC conditions and reporting requirements of the DENR-EMB;
- Submission of Compliance Monitoring Report (CMR) in accordance with the specified format in the implementing rules and regulations for Philippine Environmental Impact Statement (PEIS) System; and
- Monitor the actual project impacts vis-à-vis the predicted impacts and management measures presented in the EPRMP Report.